AIAA93-0303
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31st Aerospace Sciences Meeting & Exhibit
January 11-14, 1993 / Reno, NV

ENVIRONMENTAL MONITORING OF SPACE SHUTTLE LAUNCHES AT KENNEDY SPACE CENTER: THE FIRST TEN YEARS

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Abstract

Space Shuttle launches cause local environmental impacts primarily through formation of a launch cloud that produces acidic deposition. This cloud results from the interaction of exhaust of the solid rocket boosters (SRB) and deluge water. Primary constituents include aluminum oxide and hydrochloric acid (HCl). Deposition rates of HCl in the near-field range up to 125 g/m^2; near-field effects are typically limited to less than 1.5 km from the launch pad. Total area impacted after 43 launches was 119 ha. Acute effects of near-field deposition include vegetation damage, fish kills, and temporary increases in available metals in water and soils. Occasional mortality of terrestrial fauna is also observed. Both surface waters and local soils are well buffered, and cumulative declines in pH have not occurred. Vegetation changes from repeated near-field deposition include loss of sensitive species, decline in shrub cover, and increasing bare ground. Far-field deposition occurs over a wider geographic area, 18148 ha after 43 launches. Rates of far-field HCl deposition range from <25 mg/m^2 to about 5000 mg/m^2. Acid spotting on vegetation and structures occurs from far-field deposition but cumulative effects have not been found. Deposition is predicted by the Rocket Exhaust Effluent Diffusion (REED) model. Comparisons of predicted and ground maps indicate that the REED model correctly predicts direction but overpredicts distance and area impacted. Potential noise impacts to some taxa have been examined, but definite effects have not been shown.

Introduction

Background

In preparing the Environmental Impact Statements for the Space Shuttle Program [20] and for Kennedy Space Center (KSC) [21], considerable effort was directed at predicting the effects of the ground cloud produced from the exhaust products of the solid rocket motors. These studies included mathematical modeling of the exhaust cloud, particularly development of the REED model [3, 20, 21], measurements of exhaust products of Titan III and Delta launches that used smaller but chemically similar solid rockets [20, 21, 25, 26], and studies of the effects of simulated exhaust effluents on plants and animals [15]. It was expected that the ground cloud would consist primarily of gaseous HCl and particulate aluminum oxide (Al_2O_3). Localized acid rain was considered possible, particularly if showers passed over the exhaust cloud [20, 21], but it was not expected repeatedly in the same area. Such acid rain events had been detected with rain following Delta [19] and Titan III [25, 26] launches. Cumulative effects on vegetation and soils were not anticipated. NASA committed to a program of long term mon-

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itoring to determine if actual impacts were those predicted (21); the role of environmental monitoring has increased over the years (13, 22, 24).

In this paper we summarize what has been learned over the past ten years on effects of Shuttle launches on terrestrial and aquatic environments of Kennedy Space Center with particular attention to characteristics and distribution of deposition from launches, effects on terrestrial vegetation and soils, and effects on water quality and organisms.

Launch Exhaust Cloud Formation

The Shuttle solid rocket boosters are the largest solid rocket motors ever built and flown. Each contains 498,950 kg of propellant. The propellant consists of an aluminum powder fuel (16%), ammonium perchlorate as an oxidizer (69.9%), a catalyst of iron oxidizer powder (0.07%), a rubber-based binder of polybutadiene acrylic acid acrylonitrile (12.04%) and an epoxy curing agent (1.96%) (23). Each SRB produces approximately 2,650,000 pounds of thrust at sea level. The exhaust from the SRBs is directed northward from the launch pads by the split flame trench.

At each launch pad, a sound suppression water system is utilized to protect the shuttle and payloads from damage by acoustical energy reflected from the mobile launch platform during launch. The system consists of an elevated 530,000 gallon (2,006,050 L) tank and associated plumbing that includes a system of six large rainbirds and 16 nozzles above the flame deflectors. At approximately 12 seconds prior to launch, the system is activated, initiating a 25 to 30 second dump of the entire water system. The system also contains an overpressure suppression system consisting of two compartments. A water spray system provides a cushion of water that is routed directly into the flame hole beneath each booster. This is supplemented by a series of water hammocks stretched across each hole in the mobile launch platform. This dual system provides a 7,000 gallon (26,495 L) water mass to dampen the pressure pulse resulting from ignition of the SRBs.

At minus 12 seconds, the sound suppression system is activated, starting flow of water onto the launch pad and structure. At minus 9 seconds, the three shuttle main engines are ignited and throttled toward full power. At T-0 the two SRBs are ignited. The initial blast hits the sound suppression hammocks and water that has been pouring onto the pad instantly vaporizing and atomizing it. The resulting mixture of deluge water, debris and exhaust chemicals explode from the flame trench at a velocity of approximately 85-100 meters per second. As the shuttle rises from the launch pad, the exit velocity and percent of SRB exhaust exiting the flame trench decay to zero. At this point, the exhaust ground cloud formation ceases and column cloud formation predominates.

During the first 10-12 seconds of a launch, a ground cloud forms that is approximately $1.4 \times 10^6 m^3$ in volume (1). This cloud is composed of the complex mixture of gases, dissolved and particulate exhaust products formed by SRB fuels, sound suppression water, and materials ablated from the physical surfaces on and around the launch pad. As horizontal velocities in the cloud decrease, the cloud cools, rises, and begins to move away from the launch site with prevailing winds.

The REED model was developed to predict launch cloud effects. Predictions are made based on inputs of meteorological data from rawinsonde readings of vertical profiles of wind direction, wind speed, air temperature, atmospheric pressure, and relative humidity from the surface to 3,048 m (10,000 ft). Early versions of this model (3) predicted gaseous HCl concentrations and Al_2O_3 deposition. Actual distribution and effects of the ground cloud differed from those originally predicted in several regards. The launch of STS-1 produced an area of severe vegetation damage north of Pad 39A and acidic deposition farther away from the pad in the direction of the prevailing winds (5). Deposition on the leaves of damaged plants was high in chlorides and aluminum. Major impacts and deposition were much closer to the launch pad than predicted by the REED model.

This pattern of launches producing an impact zone near the pad occurred consistently in subsequent launches (17). Studies were directed at understanding the mechanisms producing acidic deposition unrelated to natural clouds or rain events; these studies included ground measurements, aircraft measurements, tests using small solid rockets, and mathematical modeling (1, 27).

Anderson and Keller (1) described the mechanisms producing acidic deposition as follows: 1) acidic deposition results from the atomization of deluge water by the turbulence of the vehicle exhausts; 2) large liquid drops produced by this atomization become the core of the deposition; 3) these drops rapidly coagulate with Al_2O_3 particles and condensed water in the cloud and scavenge HCl gas. Since the mechanism producing acid deposition depends on the interaction of the rocket exhausts with the deluge water and not specific meteorological conditions, it can be expected with each launch. The Titan III and Delta launches studied previous to STS-1 used little or no deluge water and thus did not produce comparable acid deposition.

Launch Cloud Characterization: Composition And Distribution Of Deposition

Near-field Deposition

Near-field deposition is that occurring from the ground cloud sweeping turbulently across the ground, vegetation, and lagoon waters. There are two aspects to quantifying near-field deposition: geographic location and amount of deposition. For each launch, the area impacted by near-field deposition has been mapped based on the visible effects on vegetation and structures. Cumulative maps were prepared after 9 (30) and 19 launches (16). Near-field deposition patterns have been digitized using the ARC/INFO Geographic Information System (GIS) (10).

Variations in areas impacted occur with differing meteorological conditions at launch. Cumulative impacts are shown in Figures 1 and 2 and areas in Table 1 (10). Pad 39A has been used for more launches; this has enlarged the impact zone around it.

Near-field deposition was quantified for several launches (8, 9). Up to 100 bulk collectors were deployed on posts marking vegetation transects in the impact zone north of Pad 39A. The collectors were retrieved after launch and analyzed for chlorides and particulates. Isopleth maps were derived from these data (8, 9).

Table 1. Cumulative areas of near-field deposition from 43 Space Shuttle launches. Areas determined by GIS analysis of cumulative maps created by overlaying field maps of deposition from individual launches.

Number of Deposition Events	Area Impacted (ha) 39A	39B
1-3	29.7	34.8
4-6	20.7	12.3
7-9	4.6	2.8
10-13	.	2.9
10-15	4.1	.
16-20	2.0	.
21-30	5.5	.
Total	66.5	52.7

Maximum HCl deposition predicted by the REED model is on the order of 5.0-15.0 g/m^2. Deposition of chlorides in the near-field recorded from launches from Pad 39A has ranged from about 0.0-125.0 g/m^2 when winds are from the south; particulate deposition has ranged from 0.0->200 g/m^2 (8, 9). With northerly winds, the pattern of deposition is shifted. Total chloride deposition in the near-field is estimated at 3.4×10^3 kg and particulate deposition at 7.1×10^3 kg for normal launches. Deposition collected in the near-field ranges in size from submicron particulates to debris several centimeters in diameter. Materials identified include Al_2O_3, sand, shell, paint, vegetation, fire brick, and other debris dislodged by the SRB ignition blast. Observations from early launches showed that the model correctly predicted direction of launch deposition but placed these effects much farther from the launch site than they actually occurred. In 1984, the model was modified to predict gravitational HCl deposition (4). The revised model predicted higher deposition near the launch pad declining with distance in qualitative agreement with observations. Even with revisions, the REED model does not predict the near-field zone of heavy deposition produced before the launch cloud rises. Measured deposition of chlorides and aluminum in the impact area can be up to 10 times greater than the maximum prediction from the REED model.

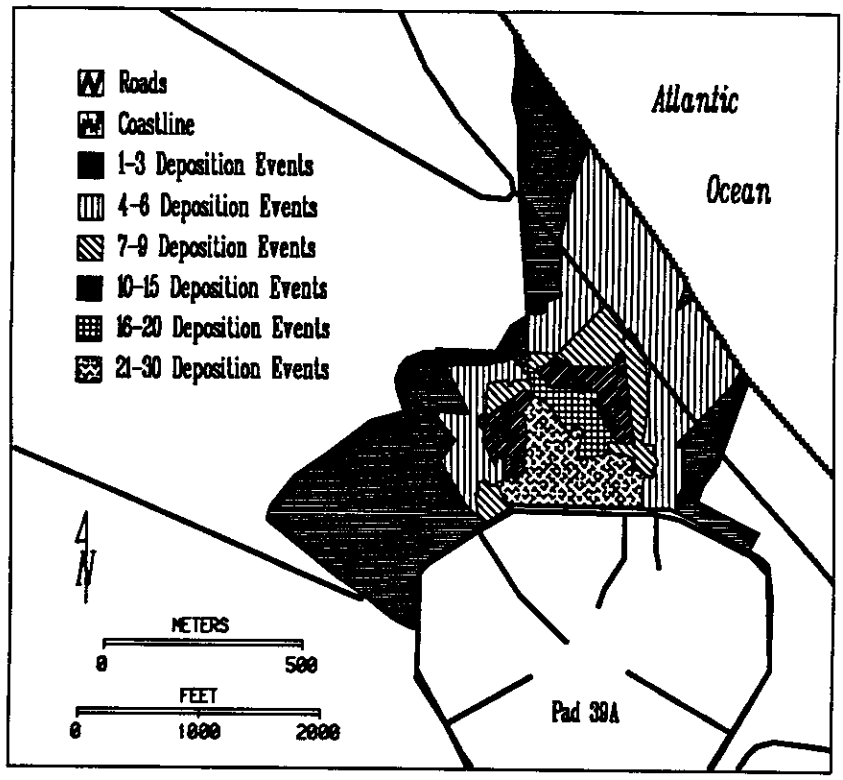

Figure 1. Cumulative pattern of near-field deposition from 43 Space Shuttle launches at Pad 39A. Pattern determined by overlaying observed field maps of near-field deposition.

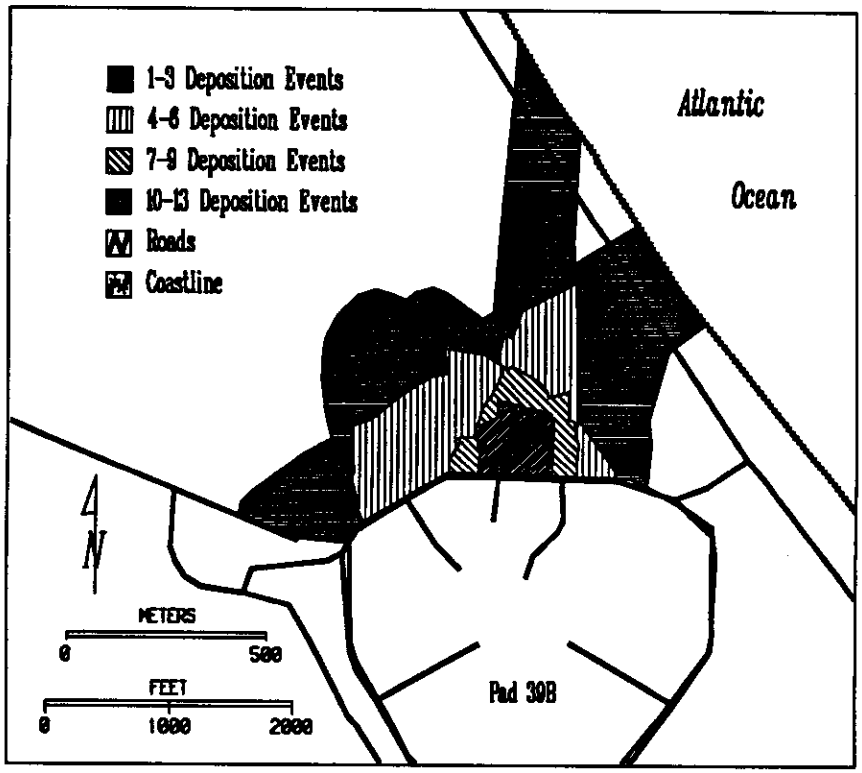

Figure 2. Cumulative pattern of near-field deposition from 43 Space Shuttle launches at Pad 39B. Pattern determined by overlaying observed field maps of near-field deposition.

Far-field Deposition

As with near-field deposition, there are two aspects to far-field deposition that have been studied: geographic distribution and amount of deposition. The ground track of deposition from every launch has been mapped. The REED model and observations of launch are used to indicate probable direction of the cloud. Spots of acid or dry deposition on leaves of plants or on structures indicate that the area received deposition. Maps of cumulative deposition were prepared after 9 (30) and 19 launches (31). Maps of launch deposition have been digitized using the ARC/INFO GIS (10).

The geographic distribution of far-field deposition is far more variable than that of near-field (Figure 3), and much of KSC has received deposition from at least one launch (Table 2). Overall, the REED model has been found to correctly predict direction of deposition but to predict that it will extend farther and cover more area than is observed (10). The 25 mg/m^2 deposition isopleth cannot always be observed on the ground (31).

Quantifying the amount of far-field deposition has proved more difficult. For several of the early launches, copper plates were deployed as deposition collectors. Only STS-2 produced deposition on more than a few plates in the far-field zone (1). Given the variation in cloud direction with variable meteorological conditions, it is not feasible to deploy enough samplers to reliably sample far-field deposition.

Table 2. Cumulative areas of far-field deposition from 43 Space Shuttle launches. Areas determined by GIS analysis of cumulative maps created by overlaying field maps of deposition from individual launches.

Number of Deposition Events	Area Impacted (ha)
1	12447
2-3	4337
4-6	1156
7-11	208
Total	18148

Two methods have been used to estimate amount of far-field deposition. In the first method, we made counts of drops on horizontal structures in the path of the cloud and measured drop diameters. Using relationships developed by Anderson and Keller (1), we calculated an estimate of chloride deposition (31). The second method was a modification of techniques used to quantify insecticide deposition (2). We collected vegetation receiving deposition, washed the deposition off the leaves, determined the leaf area of the leaves washed, and analyzed the leaf washings for chloride and aluminum. Leaves were collected from the same species from sites not receiving deposition as controls. From these data, deposition per unit area was estimated (31). To compare the two techniques, we collected leaf samples as well as counting drops and measuring their diameters for one launch (31).

Quantitative estimates of far-field deposition derived from leaf washing and drop counting are near or less than that predicted by the REED model (31). In addition, there is general agreement between the two methods for sites where both were possible. Aluminum deposition was much less than that of chlorides, although the expected composition of the ground cloud has an aluminum to chloride ratio of 86.7% (21). Reasons for this difference are unknown.

Environmental Effects

Vegetation

Pad 39A. The acute near-field impacts of Shuttle launches were not anticipated in the institutional EIS (21). After the launch of STS-1 (April 12, 1981), a sampling grid of 46 vegetation transects (20 m length) was established in the impact zone defined by the first launch. Percent cover by taxon was determined along each transect using line-intercept sampling in October 1981 (6). In January 1984, subsequent to the launch of STS-9, we resampled these transects. Species composition, frequency, and cover were compared between the two periods (30). Transects were resampled in August and September 1989 before launches resumed from Pad 39A (January, 1990).

Cumulative impacts of launches through STS-9 included reduction in the number of plant species present and reduction in total cover; the

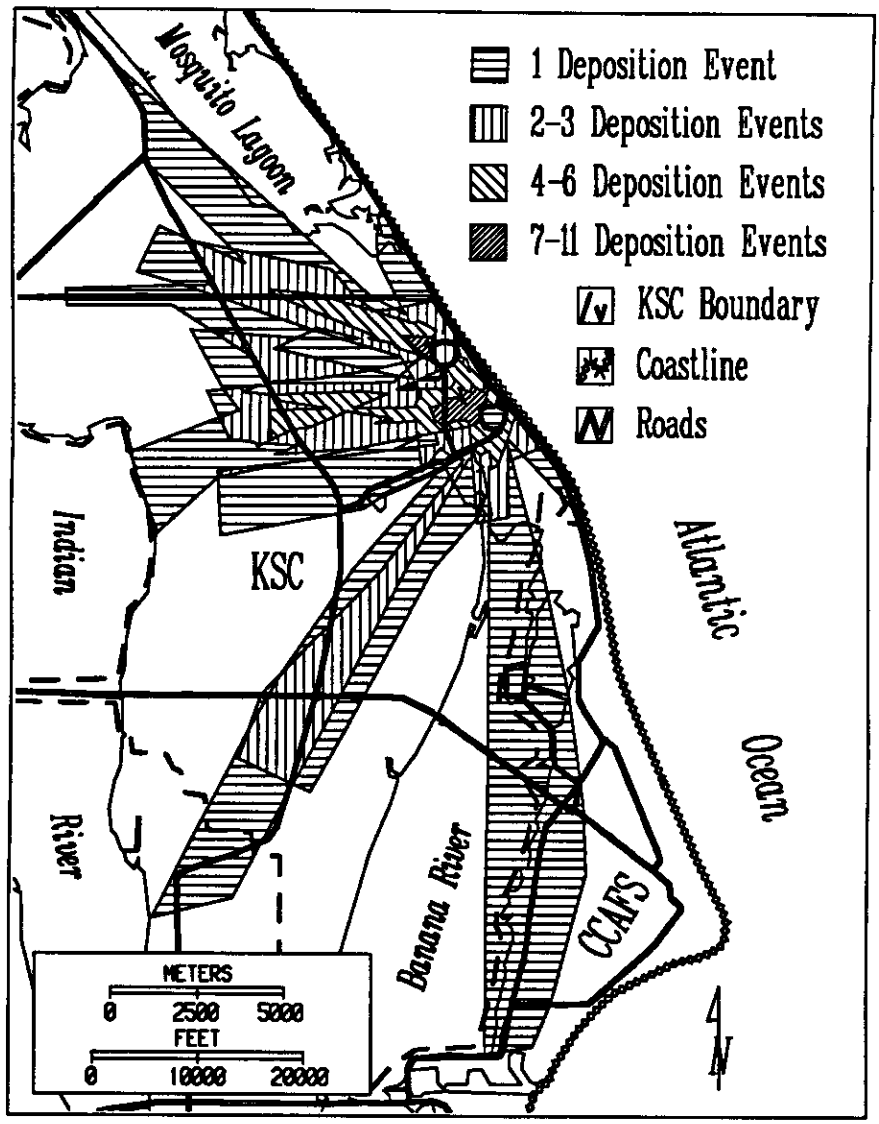

Figure 3. Cumulative pattern of far-field deposition from Space Shuttle launches. Pattern determined by overlaying observed field maps of both pad 39A and 39B far-field deposition.

reduction in total species number included both loss of sensitive species and invasion of more weedy ones but losses exceeded new invasion (30). Vegetation effects differed by strata; shrubs and small trees were eliminated by repeated defoliation more rapidly than forbs and graminoids. The community level effects consisted of retrogressive changes . These changes continued until the cessation of launches in 1986 with an increasing amount of bare ground in the most severely impacted area. Considerable regrowth occurred in the period without launches. Resumption of launches initiated another retrogressive sequence.

Dune and Strand Vegetation. The launch of STS-8 on August 30, 1983 was the first to produce acute effects on vegetation of the dunes east of Pad 39A. To assess damage to dune vegetation, we established a transect across the zone of impacted vegetation and located plots in areas of no, light, moderate, and heavy damage. We estimated percent cover by species and percent

damage to each species. In similar fashion, we established a transect across the zone of damaged strand vegetation and located plots along it to estimate percent cover and percent damage. We calculated a weighted mean percent damage for each plot from the percent cover and percent damage data. To estimate the sensitivities of individual species, we divided the plots into areas of moderate and heavy damage and calculated mean damage for each species.

The launch of STS-9 produced similar damage to dune and strand vegetation in an area north of that impacted by STS-8. Damage was assessed using plots on transects across the zone of damage as before. Six plots each in dune and strand were marked and resampled after six months to determine recovery.

Vegetation damage to strand and dune vegetation from STS-8 and STS-9 was similar. Mean percent damage to dune vegetation ranged up to 58% and damage to strand vegetation up to 76%. In both dune and strand, only minor damage attributable to launch could be detected after six months (30). Rankings of species sensitivity were similar for both launches. On the dunes, herbs with thin leaves such as Helianthus debilis and Heterotheca subaxillaris were sensitive as were some shrubs with succulent leaves (e.g., Iva imbricata). The dune grasses, Uniola paniculata and Panicum amarum, were resistant. In strand, herbs such as Monarda punctata and Flaveria linearis were sensitive. Shrubs varied in sensitivity with Borrichia frutescens and Baccharis halimifolia sensitive, Quercus geminata resistant, and Myrica cerifera intermediate. Most grasses were resistant as were heavily cutinized plants like Opuntia spp. (30).

Pad 39B. We established and sampled 31 vegetation transects in the Pad 39B area in 1984 before any launches occurred from this facility. In the expected impact area near Pad 39B, there is a greater proportion of open water to terrestrial habitat; therefore, a grid system was not used. We located transects on strips of land between and around the impoundments. Transects used were 15 m long, and vegetation was recorded in two height classes, >0.5 m and <0.5 m, as we have used in most other vegetation sampling on KSC.

The Challenger launch on January 28, 1986 had only minor impacts on vegetation, and the vegetation recovered during the greater than 2-year hiatus before the launch of STS-26 on September 29, 1988. We resampled vegetation transects in the Pad 39B area in the summer of 1988 before launches resumed and four years after baseline sampling. Transects were resampled in December, 1991 after 12 launches had occurred from Pad 39B.

Five vegetation types: wax myrtle, sea oxeye, mangrove, scrub, and salt marsh dominated by Distichlis spicata occurred before launches began. Composition of the types changed slightly between 1984 and 1988 but major shifts in dominant species did not occur. By December, 1991, loss of shrub species had occurred in the most frequently impacted transects.

Far-field. Individual launches can produce damage to foilage of vegetation at far-field sites. Observations indicate that areas receiving 1000 mg/m^2 chlorides experience damage from acid etching of the leaves; sensitive species can be damaged by 100 mg/m^2 chlorides (31). Far-field deposition is sufficiently dispersed and variable launch-to-launch that successive launches seldom affect the same areas. No changes in plant community composition or structure due to cumualtive effects of far-field deposition have been seen.

Baseline data on vegetation (33) and soils (18) of KSC were collected as part of the preparation of the institutional EIS (21). Since the acute near-field effects had not been predicted, none of the sites sampled were within the plume zone of Pad 39A. Vegetation in the impact zone was sampled before STS-2 (6). Cumulative effects became apparent by STS-4 (17). These cumulative changes are comparable to those occurring around pollution sources such as smelters that produced sulfur dioxide emissions (11, 12, 32) or fluoride emissions (32), although the magnitude of the areas impacted by Shuttle launches is much smaller. Comparable patterns of vegetation changes have been described for chronic effects of radiation (34, 35, 36) and termed retrogression. Retrogressive changes in vegetation in the Pad 39A impact zone continued with increases in the area of bare ground until the suspension of Shuttle flights in 1986. Vegetation changes occurring at Pad 39B are similar to those at Pad 39A, indicating the generality of this pattern. Regrowth ocurred in the Pad 39A area in the period without launches, in-

dicating that the system had not degraded to the point where it would not support plant growth. The vegetation that reestablished was not always present before. Zammit and Zedler (37) found that simulated acid deposition affected seedling germination and establishment of species native to Vandenberg Air Force Base, California. These effects have not been examined for species at KSC.

Cumulative effects have been observed only in areas receiving repeated near-field acid deposition. Dune vegetation has been damaged by some launches but has recovered, since the same areas have not been impacted repeatedly. Far-field deposition has not caused changes in plant community composition or structure (31).

Responses of native and cultivated species to predicted constituents of Shuttle exhaust were examined before STS-1 (15). Much of that work focused on gaseous hydrogen chloride, aluminum oxide, and mixtures resulting from burning solid rocket fuel. In additional work, Heck et al. (15) found that: 1) increased relative humidity increased leaf damage at some concentrations of HCl, 2) misting leaves with water before exposure to HCl increased foliar injury, and 3) damage to foliage differed between exposure of plants to dry HCl as a gas and an acid aerosol of hydrochloric acid of the same concentration. They suggested that HCl may cause foliar injury by three different mechanisms: entrance of gas through the stomates, a surface acid effect, and cuticular absorption (15).

In the exhaust cloud formed by Shuttle launches, much of the HCl is in the liquid phase as an acid aerosol and not a gas. The mechanism of foliar damage is probably primarily due to acid effects on leaf surfaces. Sensitivities of native species to exposure to this acid deposition are not identical to sensitivities to exposure to HCl gas. For example, Borrichia frutescens, Helianthus debilis, and Heterotheca subaxillaris are more sensitive to acid deposition than to gaseous exposure, Uniola paniculata and Quercus virginiana are relatively resistant to both, and Baccharis halimifolia and Hydrocotyle umbellata are relatively sensitive to both (15, 30).

Soils

Pad 39A. Soils were not sampled with the original vegetation sampling at Pad 39A. When the vegetation transects were resampled after STS-9, we collected soil samples from the 0-15 and 15-30 cm layers near each transect. After 24 launches from Pad 39A, we resampled soils from the 0-15 cm layer, since changes caused by acid deposition would be expected to be most evident in the surface soils. Soils were analyzed for pH, conductivity, organic matter, exchangeable Ca, Mg, K, Na, NO_3-N, NH_4-N, Al, available P, Cu, Fe, Mn, and Zn using standard methods.

Initial inspection of the soils data indicated considerable heterogeneity in soil conditions in the impact area. We used cluster analysis (Ward's method) (28) with the soil variables conductivity, organic matter, Ca, Mg, K, Na, NO_3-N, NH_4-N, Fe, and Zn from the post-STS-9 sampling to determine if more homogeneous groups of soils existed. Within groups, we compared soil variables after 9 launches to those after 24 launches.

Cluster analysis of the post STS-9 samples produced two distinct groups of soils that could be characterized as saline (N=9) and non-saline (N=31). Within these groups, changes between conditions after 9 launches and after 24 launches differed. In the non-saline soils, there were increases in conductivity, Ca, K, Na, and Zn and decreases in P, NO_3-N, NH_4-N (Table 3). In the saline soils, there were increases in Ca, K, Na, Zn, and P but not conductivity and decreases in NH_4-N but not NO_3-N.

Pad 39B. We collected soil samples from the 0-15 cm and 15-30 cm layers from near the 31 vegetation transects with the initial sampling in 1984. A subset of 7 transects was resampled in 1988, and all transects were resampled in 1991. Analyses of these samples and data are not complete.

Soil studies completed previous to STS-1 indicated that strong solutions of hydrochloric acid would leach cations (Na, Ca, Mg) and certain metals (Al, Fe, Mn, Ni, Zn, Co) from KSC soils (18). Leaching differed among different soil types, for different cations and metals, and with varying concentrations of hydrochloric acid. Madsen (18) suggested that if several rain events with pH 1.0 occurred on the same soil, then leaching could become significant. Increases in conductivity, Ca, K, and Na between 9 and 24 launches may be due to leaching of soil material including shell fragments; increases in zinc could be from soil leach-

Table 3. Comparison of non-saline and saline Pad 39A soils (0-15 cm) sampled after 9 launches and after 24 launches.

Variable	Non-Saline Soils 9 Launches	Saline Soils 24 Launches	9 Launches	24 Launches
pH	7.11	7.87	7.96	8.15
Conductivity (µmhos/cm)	350 (410) N=31	1135*** (1602) N=33	8300 (4600) N=9	11092 (4504) N=9
Organic Matter [a] (%)	2.6 (1.3) N=31	2.6 (1.2) N=33	4.5 (3.5) N=8	5.2 (2.6) N=8
P[c] (mg/kg)	2.05 (3.13) N=31	0.87* (1.43) N=33	0.11 (0.08) N=9	0.21** (0.12) N=9
NO_3-N[b] (mg/kg)	6.65 (5.76) N=31	3.66*** (2.12) N=33	3.17 (2.00) N=9	3.48 (2.14) N=9
NH_4-N[b] (mg/kg)	3.34 (5.16) N=31	1.56* (1.27) N=33	5.22 (3.81) N=9	2.41* (2.40) N=9
CEC (meq/100 g)	0.82 (1.04) N=31	0.89 (1.03) N=33	4.34 (5.32) N=9	2.15 (3.12) N=9
Al[b] (mg/kg)	0.22 (0.17) N=31	0.19 (0.14) N=33	0.16 (0.10) N=9	0.12 (0.04) N=9
Cu[c] (mg/kg)	0.33 (0.43) N=31	0.60 (1.41) N=33	0.48 (0.37) N=9	0.41 (0.23) N=9
Fe[c] (mg/kg)	15.12 (9.57) N=31	16.97 (8.15) N=33	32.48 (16.70) N=9	36.81 (13.51) N=9
Mn[c] (mg/kg)	1.474 0.799 N=31	1.338 (0.630) N=33	2.654 (1.712) N=9	2.307 (0.631) N=9
Zn[c] (mg/kg)	5.60 (7.22) N=31	8.92* (8.25) N=33	2.32 (1.44) N=9	3.82* 1.96 N=9
Ca[b] (mg/kg)	1560.3 (393.2) N=31	1905.8*** 524.8 N=33	1960.9 (293.4) N=9	2409.8* (655.8) N=9
Mg[b] (mg/kg)	195.7 (97.2) N=31	1028.4 (4310.3) N=33	1216.5 (462.5) N=9	7662.5 (12311.9) N=9
K[b] (mg/kg)	164.2 (90.2) N=31	238.6*** (129.9) N=33	555.0 (231.7) N=9	851.6* (386.1) N=9
Na[b] (mg/kg)	197.66 (340.51) N=31	844.96** (1574.61) N=33	8077.63 (4748.53) N=9	12295.74** (4091.64) N=9
H^+	7.6848623E-8 (3.6475097E-7) N=31	1.336537E-8 (6.636011E-9) N=33	1.0918906E-8 (5.2576213E-9) N=9	7.100451E-9 (5.227248E-9) N=9

Key:
* = $P \leq .10$ ** = $P \leq .05$ *** = $P \leq .01$
[a] = Significance tests performed on transformed (arcsine) data.
[b] = exchangeable
[c] = available

ing or from deposition of material derived from paint or plating on pad structures.

Soils in the impact area were well buffered; even after 24 launches, soil pH was still alkaline. Since pH was still high, the aluminum deposited by the exhaust cloud was not in an exchangeable form.

In preparing for launches at Pad 39B, vegetation and soils in the expected impact area were sampled before any launches so that baseline data would exist. Vegetation changes to date are consistent with what happened at Pad 39A. Some of the soils in the Pad 39B area were acid to begin with; however, these soils have not yet received heavy launch deposition.

Soil Microcosms. In order to establish the direct impact of launch cloud deposition on soils, eighteen soil microcosms were established in January 1984. The microcosms contained Canaveral Series soils (a mixed hyperthermic aquic udipsamment). They were placed at launch and control sites in the vicinity of Pad 39A. Each microcosm (38 cm x 50 cm x 23 cm) contained 2.5 cm of washed quartz gravel drainage material, 10 cm of Canaveral Series soil and a sod mat approximately 10 cm thick, comprised of native vegetation. Eighteen hours prior to each launch, nine of the microcosms were covered with polyethylene film to prevent direct deposition from the launch cloud, but to allow gaseous HCl exchange. Immediately post-launch (within 24 hours), all microcosms were uncovered and leached with deionized water at a rate approximating 5 cm of rainfall, and the leachate was collected for chemical analysis. Samples were collected at periodic intervals, both immediately post-launch and between launches, through November 1985. All microcosms remained uncovered and in position in the field between launches.

Soil leachate pH decreased immediately post-launch in those microcosms exposed to the launch cloud. The temporary pH depression in exposed soils associated with acidification each launch increased by 4.3 pH units with exposure to 23 successive launches for highly exposed soils. During any one event, leachate pH recovered to pre-launch values within seven days. Over the course of the study, a cummulative decline of 0.35 pH units in the background soil pH was noted in the highly exposed soils.

With each loading of HCl by the Shuttle exhaust cloud, metal concentrations increased in soil leachates due to increased metal solubility at lower pH. Between launches, as leachate pH recovered to near background levels, metal concentrations in the leachate declined, probably due to the formation of less soluble metal oxides and hydroxides at circumneutral pH.

Potassium ion concentrations were highly variable, both immediately post-launch and during periods between launches. Intermediately exposed soils (14 launches) exhibited K leaching to a greater extent than did the soils exposed to 23 launches or the control soils. Elevated Ca and Mg ion concentrations immediately post-launch and between launches for intermediately exposed and highly exposed soils indicated a decline in buffering capacity with time due in part to dissolution of shell fragments prevalent in these coastal soils.

Surface Waters

Original projections of impacts from Shuttle launches did not include water quality degredation (20). However, STS-1 produced a significant fish kill in the lagoon approximately 450 meters north of the SRB flame trench. This fish kill was found to be the direct result of acidification of shallow surface waters resulting from deposition of HCl in the ground cloud (14). Intensive water quality monitoring and laboratory simulation activities, to document impacts and recovery of the lagoon, were conducted during the next 10 launches. Recording pH meters were deployed throughout the lagoon to document the area and depth of chemical alterations. The acidification event was found to correspond spatially with areas directly impacted by the ground cloud deposition and runoff of the deluge water from the north side of the launch pad. Figure 4 shows a typical pH recording from the lagoon during and after launch of STS-. Background pH in the estuarine system generally ranges between 7.8 and 8.6 units. At launch, the surface layer of the lagoon receives up to 1700 kg of HCl from deposition. This acid mixes downward into the water column through advection and diffusion, eventually impacting approximately the upper 1.5 m. The rate of mixing is driven primarily by windspeed and direction across the lagoon. Levels of impact are highly variable spatially and temporally, depending on meterological conditions at the time of launch. Maximum pH reductions (about 6 to 7 units) are found at the sur-

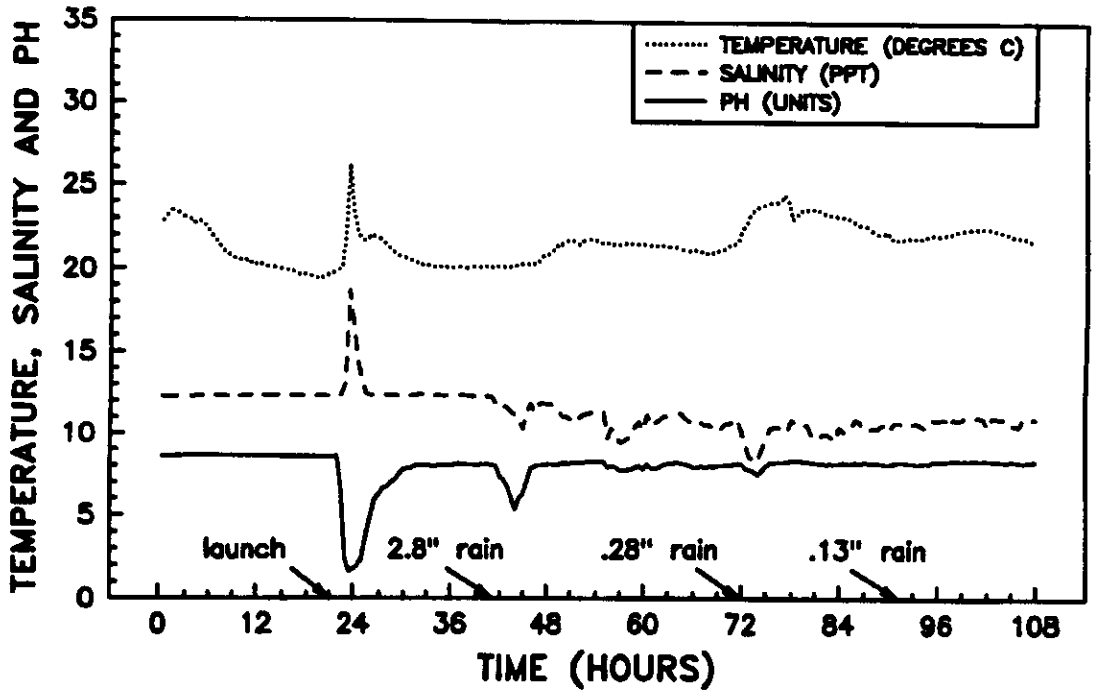

Figure 4. Record of temperature, salinity and pH in the lagoon north of Pad 39A after STS-51D (4 April 1985). The initial pulse of HCl deposition from launch caused a sharp decline in pH and increase in salinity. Subsequent rainfall washed additional HCl originally deposited on vegetation or soil into the lagoon.

face and in the area adjacent to the stormwater drainage ditch in line with the flame trench at each pad. In these areas, pH depression may be acute and lethal to organisims utilizing gills for respiration. Minimal effects are observed around the edges of the ground cloud footprint and at depth where buffering and dilution minimize chemical impacts.

A series of laboratory simulations (7) and field studies were conducted to assess the nature and magnitude of large scale chemical reactions occuring between surface waters and the exhausted HCl. Surface and ground waters in the region around the launch pads are highly buffered, as a result of local soils and geological conditions, with total alkalinity values typically ranging between 120 and 200 mg/l as $CaCO_3$. As with the soils in the region, this aquatic buffering system reacts readily with the exhausted HCl to produce $CaCl_2$, CO_2, and H_2O. The release of CO_2 (which may form carbonic acid in solution or small bubbles and foam) and the presence of free H^+ ions during the period of reaction and mixing results in the rapid depression of pH. Advective and diffusive mixing during the 48 to 72 hours post-launch have been found to return pH readings and alkalinity measurements in the lagoon to pre-launch levels. Dreschel and Hall (9) estimate that 4,700 kg of acid neutralizing capacity is required to buffer the acid deposition from the launch cloud. In the aquatic system, sources of alkalinity replenishment include surface mixing, stormwater runoff, and ground water inputs.

Assessments of the possible impacts of launch exhaust on metals in the aquatic environment have been addressed in a cursory manner. Table 4 summarizes water chemistry data collected pre- and post-launch. As expected, during the period of reduced pH metals become more soluble and their concentrations in the water column increase dramatically. As normal pH levels return to the area of impact, metal concentrations return to pre-launch levels. To date no long-term elevations of metal concentrations in the water column have been observed.

Table 4. Results of chemical analyses of surface waters from four locations in the impoundment north of launch Pad 39B pre- and post-launch of mission STS-26 and STS-27.

Date		pH	Al	Cd	Cl^-	Conduc.	Fe	Total Alkalinity	Total Dissolv. Solids	Total Hard.	Zn
September 28 Pre-Launch	Mean	9.3	0.15	0.05	8774	26860	0.08	128.8	15092	2722	0.01
	Standard Deviation	0.3	0.02	0.05	1032	2763	0.02	20.9	1655	294	0.001
September 29 Post-Launch	Mean	6.8	2.32	0.39	9278	28220	1.94	54.3	16448	2950	1.06
	Standard Deviation	2.8	3.29	0.38	821	2727	2.57	45.6	1648	366	1.38
October 6 One Week Post-Launch	Mean	8.8	0.11	0.13	9651	31300	0.10	170.0	17233	3118	0.02
	Standard Deviation	0.2	0.10	0.02	1093	858	0.06	14.6	409	81	0.01
November 30 Pre-Launch	Mean	8.1	0.10	0.40	5279	16025	0.09	169.5	9617	1255	0.01
	Standard Deviation	0.7	0.00	0.14	458	1417	0.02	40.3	3098	44	0.00
December 2 Post-Launch	Mean	7.6	0.50	1.06	4922	15950	0.29	103.1	8566	1365	0.57
	Standard Deviation	1.8	0.53	0.84	158	1103	0.95	65.8	1306	90	0.72

Fish and Wildlife

The John F. Kennedy Space Center and associated Merritt Island National Wildlife Refuge are a part of one of the most biologically diverse coastal ecosystems in the continental United States. This unique environment and the large number of federally protected species represent a special challenge for NASA. Environmental impacts on fish and wildlife resources in the vicinity of the launch pad resulting from Shuttle launch exhaust have been classified as short-term acute and long-term chronic. For every launch there is potential for acute impacts to fish and wildlife in the vicinity of the pad resulting from noise, blast debris, heat, and toxic chemicals (primarily HCl). Chronic impacts result from subtle alterations in habitat and potentials for bioaccumulation of pollutants that may be released into the environment. However, after ten years, localized wildlife impacts appear minimal and managable when considered at the landscape scale.

For each launch, there is a fish kill that occurs in the shallow surface waters of the lagoon (Pad 39A) or impoundment (Pad 39B) north of each pad in line with the SRB flame trench. This fish kill is the direct result of the surface water acidification that often exceeds 5 pH units. Hawkins et al. (14) found that the rapid drop in pH produced severe damage to the gill lamella of fish exposed to the near-field launch deposition. Field surveys conducted after each launch have verified this event which is generally limited to the shallow shoreline closest to the pad and the stormwater ditches leading away from the north side of the pad surface. At Pad 39A the fish kill appears limited to a band of shallow water approximately 10 m wide (the 0.5 m depth contur). In deeper open water, fish dive below the area of acidification avoiding the rapid drop in pH. At Pad 39B, the fish kill may cover a larger area and involve a larger number of individuals because the impoundment water depth is generally less than 0.5 m year round, and the fish are not able to avoid the rapid drop in pH. In every event the fish kill occurs in direct relation to the spatial pattern of the near-field deposition footprint.

Species observed killed after almost every launch include the rain water killifish (Lucania parva), mosquito fish (Gambusia affinis), sheepshead

minnow (Cyprinodon variegatus), and sailfin molly (Poecilia latipinna). The numbers of individuals observed after each launch are highly variable, depending on such factors as deposition pattern, seasonal water depths, and seasonal reproductive activity (presence of large numbers of juveniles). These species are aggressive invaders of open habitats and begin to recolonize the area within several days after each launch. This rapid immigration is possible because only a small portion of the larger contiguous population is actually impacted. Also, these species are tolerant of a wide range of environmental conditions and are extremely prolific, making them ideally suited for life in the shallow brackish waters around the pads. Other taxa that have been observed less frequently (one to ten launches) have included mullet (Mugil cephalus), sheepshead (Archosargus probatocephalus), black drum (Pogonias cromis), needle fish (Strongylura spp.), lady fish (Elops saurus), and red drum (Scianops ocellatus).

Acute impacts to wildlife populations at KSC appear minimal. The majority of birds are able to flee the pad area in a fright response to the ignition of the Shuttle main engines 7 seconds prior to the ignition of the SRBs. On occasion some individual animals are caught in the exhaust blast and are killed or injured. Examples of species observed in the impact zone include armidillo, marsh rabbits, snowy egret, killdeer, frogs, and alligators (present but not harmed). Because injured animals tend to hide in burrows or dense vegetation, it is believed that the number is probably greater than observed. To date no federally listed threatend or endangered species have been directly identified as being killed as a result of the launch event.

Two taxa have been given special consideration due to possible impacts that may result from the extreme noise levels near the pads at the time of launch. Low frequency noise levels in the 145-160 dB range have been measured near the launch pad. The Florida Scrub Jay (Aphelocoma coerulescens coerulescens), a species listed as threatened by the U.S. Fish and Wildlife Service, inhabits shrub vegetation in the vicinity of the two launch pads. This species forms monogomous breeding pairs that mate for life and defend territories. Field assessments have included trapping and color banding to allow the identification of individuals in the vicinity of the launch pads. After launch, observations were made of the behavior of individuals and their responses to alarm calls. To date no acute effects have been documented. A second species of concern is the Wood Stork (Mycteria americana) which has nested at the Bluebill Creek Rookery approximately 750-800 m south of Pad 39A. During the last three nesting seasons, observations of nesting success have been conducted at the colony to document possible adverse effects resulting from launch noise and or acid deposition. It was speculated that the high noise levels, fright response, or acid deposition on eggs may interfere with some aspect of nesting success. In December 1989 a severe freeze damaged the black mangroves (Avicennia germinans) in which the storks nested. These trees have deteriorated in subsequent years and become less suitable or unsuitable for stork nesting. During the period of observation, success of Wood Stork nesting at the Bluebill Creek site continually declined, with total failure during the 1992 nesting season. Based on the field techniques utilized and other changes that have occurred in the landscape (loss of large mangroves, high water levels in feeding habitat, frequent storms) during the period of observation it has not been possible to positively define the reason for the decline in nesting success. However, other taxa utilizing the Rookery continue to nest successfully at the site.

Summary

Shuttle launches produce local environmental effects primarily through the formation of a launch cloud that produces acidic deposition. This deposition causes acute vegetation damage in the near-field environment and frequently fish kills in the lagoon or impoundment near each pad. Repeated launches produce cumulative changes in plant community composition and structure. Soil microcosm studies suggest that repeated exposure to near-field deposition could decrease buffering capacity; such declines have not yet occurred in soils in the field. Temporary decreases in pH increase metal availability in soil microcosms and surface waters; however, availability declines with return to pre-launch pH. Soils affected by repeated launches show increases in Ca, K, and Na, probably due to dissolution of shell material, and in Zn, possible from material derived from pad structures. Direct effects to terrestrial fauna include occasional motality to birds, mammals, amphibians

or reptiles in the near-field area. This appears to be a minimal impact. Far-field deposition has occurred over a wide area of KSC, but cumulative effects are not apparent. The REED model adequately predicts direction of the launch cloud deposition but frequently overpredicts both area and distance of deposition. Noise has the potential to impact wildlife and produces a startle response in birds, but other effects have not been demonstrated.

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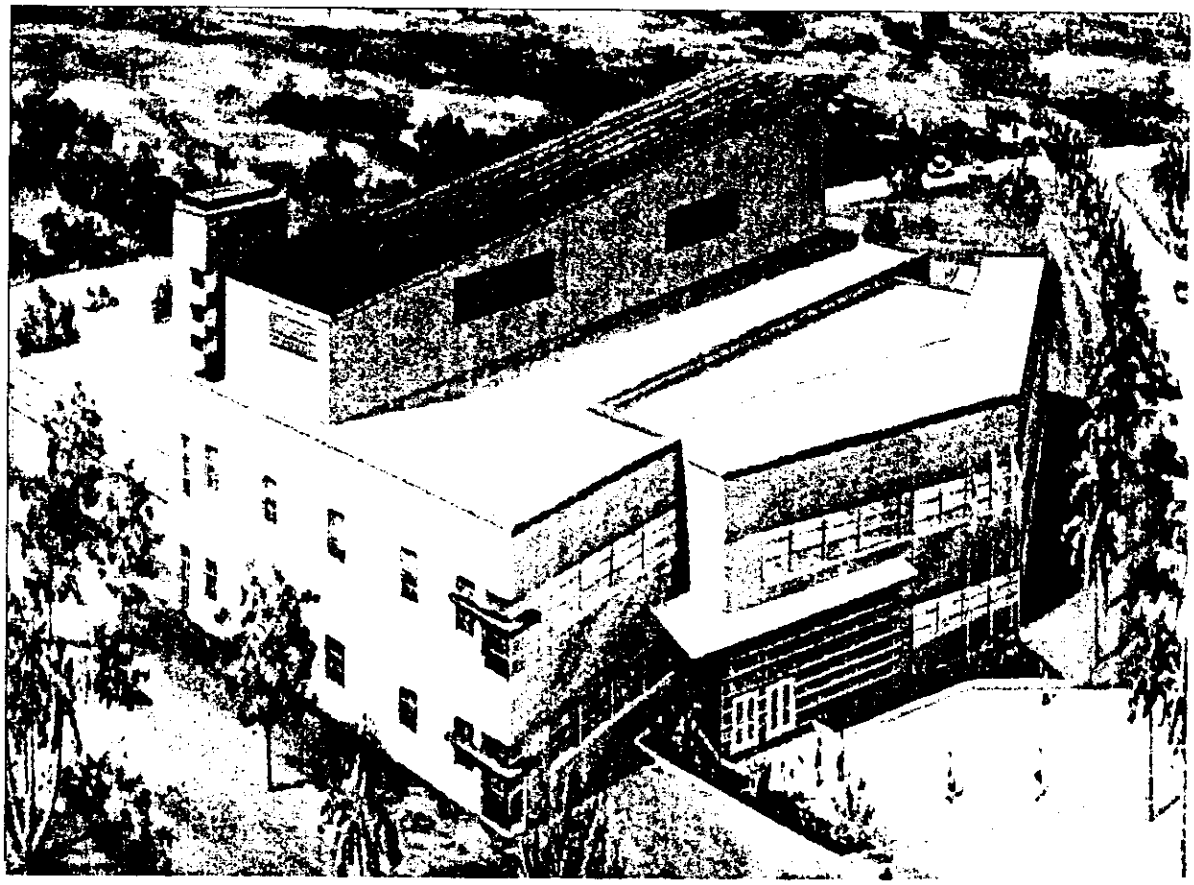
ENVIRONMENTAL ASSESSMENT
FOR
THE SPACE EXPERIMENTS RESEARCH AND PROCESSING LABORATORY



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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March 2000

ENVIRONMENTAL ASSESSMENT
FOR
THE SPACE EXPERIMENTS RESEARCH AND PROCESSING LABORATORY

Prepared By:
The Dynamac Corporation

For the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHN F. KENNEDY SPACE CENTER
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March 2000

ENVIRONMENTAL ASSESSMENT
FOR
THE SPACE EXPERIMENTS RESEARCH AND PROCESSING LABORATORY, Kennedy Space Center, Florida

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Abstract

This Environmental Assessment (EA) addresses the proposed action to construct the Space Experiments Research and Processing Laboratory (SERPL) on approximately 40 acres of land adjacent to State Road 3 south of NASA Causeway, at Kennedy Space Center (KSC) Florida. This facility will provide for the preparation and processing of all biological experiments launched to and returned from the International Space Station (ISS).

Two alternative locations plus a third No Action alternative were evaluated to determine the extent of impacts to the environment at KSC. The two alternatives evaluated were for a 20-acre site instead of 40 acres. The 40-acre Proposed Action location would include the SERPL facility and have acreage available to construct an education facility. The two alternative sites would only include the SERPL facility.

EXECUTIVE SUMMARY

This Environmental Assessment (EA) addresses the proposed action to construct the Space Experiments Research and Processing Laboratory (SERPL) on approximately 40 acres of land adjacent to State Road 3 south of NASA Causeway, at Kennedy Space Center (KSC) Florida. The SERPL would provide facility support for management and technical services enabling efficient and safe processing of payloads for life science research programs conducted in concert with the Space Transportation System (STS) for the Space Shuttle and the International Space Station (ISS). The facility is proposed to be a two-story facility with maximum utilization of space providing the best possible support for these programs. This facility would be a central location for life science laboratories, animal and plant care facilities, aquatic facilities, supplies, office and meeting space. This facility would also be utilized by visiting scientists, and advanced education entities, enabling them to conduct experiments in a technologically superior facility. The proposed 40-acre site would have additional land available for possible future expansions.

Two alternative locations were evaluated to determine the extent of impacts to the environment at KSC. Alternative 1 is located in the industrial area adjacent to Contractors Road. Alternative 2 is located south of the Headquarters Building located in the KSC Industrial Area. Both of these locations were evaluated for a 20-acre site instead of a 40-acre site. It has been discussed that an education facility, that would be available for State University System schools and private scholastic entities, be constructed in the vicinity of the SERPL due to the similarities in proposed activities. However, due to the timeframe allotted for the SERPL facility, this additional educational facility would not be constructed at this time. Therefore, it will not be discussed in this document. The Proposed Action location was evaluated on a location large enough for this possible expansion, while the two alternatives were evaluated only for the SERPL facility.

This document describes those portions of the KSC environment, which relate to each of the alternatives. Issues identified are transportation, utilities, air quality, biological resources, threatened and endangered species, cultural resources, geology and soils, noise, surface water quality, groundwater quality, socioeconomics, and land use.

The results of the assessment of these environmental issues indicate that minimal impacts at the Proposed Action site are to transportation due to the development of a new primary access road to KSC; increased loads to existing utilities; surface water impacts due to site preparation and construction of the facility and stormwater system; threatened and endangered species due to the removal of habitat, including upland and hammock areas; and to socioeconomics due to the temporary addition of construction workers to the local workforce and the addition of personnel to support the ISS. There are minor expected impacts to transportation once the new roadway is in operation. This is due to the complete re-direction of traffic onto KSC from south Merritt Island. There are also minor impacts expected to biological resources due to impacts to hardwood hammocks which are a sensitive area on KSC. Minor impacts are also expected to air quality at the Proposed Action location due to land clearing, vegetation removal, and heavy equipment operation. Minor impacts are expected due to the increased noise levels during construction of the SERPL. This would be a temporary impact and is not expected to have lasting affects. There are major impacts to land use at the Proposed Action location. The proposed 40-acre site would be removed from under the management of the Merritt Island National Wildlife Refuge, and turned over to NASA managed property. No impacts are expected to cultural resources, geology and soils, or groundwater.

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APPENDIX A - TYPICAL WILDLIFE SPECIES	

List of Abbreviations and Acronyms

AC	Acres
ADA	American with Disabilities Act
ALS	Advanced Life Support
ASCE	American Society of Civil Engineers
ASTs	aboveground storage tanks
BMPs	Best Management Practices
CBS	Controlled Biological Systems
CCAFS	Cape Canaveral Air Force Station
CNS	Canaveral National Seashore
CO	carbon monoxide
COE	Army Corps of Engineers
dBA	decibels, weighted to the A-scale
EA	Environmental Assessment
EO	Executive Order
EPA	Environmental Protection Agency
FCREPA	Florida Committee on Rare and Endangered Plants and Animals
FPL	Florida Power and Light
ft	feet
ft^2	square feet
gal	gallons
gsf	gross square feet
ha	hectares
ISS	International Space Station
in	inch
kg	kilogram
km	kilometers
KSC	Kennedy Space Center
kVA	kilovolt/amps
L	liters
m	meters
m^2	square meters
mgd	million gallons per day
mg/l	milligrams per liter
mi	miles
MINWR	Merritt Island National Wildlife Refuge
mLd	million liters per day
MMPA	Marine Mammal Protection Act
N/A	Not Applicable
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NGVD	National Geodetic Vertical Datum
NHPA	National Historical Preservation Act
NMI	NASA Management Instruction
NO_2	nitrogen dioxide
NPS	National Park Service
O&C	Operations and Checkout

List of Abbreviations and Acronyms (continued)

O_3	ozone
OFW	Outstanding Florida Waters
OSHA	Occupational Safety and Health Administration
PAMS	Permanent Air Monitoring System
SERPL	Space Experiments and Research Processing Laboratory
SO_2	sulfur dioxide
STS	Space Transportation System
STP	Sewage Treatment Plant
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
VAB	Vehicle Assembly Building

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1.0 PURPOSE AND NEED FOR ACTION

1.1 Purpose

The purpose of the proposed action is to construct a new state-of-the-art research laboratory for Cape Canaveral Spaceport and world-class scientists. The Space Experiments Research and Processing Laboratory (SERPL) will house various programs including the Space Station Life Sciences, Controlled Biological Systems (CBS) efforts supporting the Johnson Space Center's Advanced Life Support (ALS) Program, the environmental and ecological monitoring function of the John F. Kennedy Space Center (KSC) Biomedical Office, and support laboratories for microbiology and chemistry. This facility will provide for the processing and preparation of all biological experiments launched to and returned from the International Space Station (ISS).

1.2 Need for Action

As the primary launch site for Space Shuttle missions, Cape Canaveral Spaceport (Figure 1) and the State of Florida, have the requirement to provide state-of-the-art facilities in support of new technological advances that have come to pass in the space exploration industry.

Currently, the laboratory facilities for pre-launch and post-landing processing of life science experiments and organisms are located in Hangar L on Cape Canaveral Air Station and in the Operations and Checkout (O&C) Building on KSC. The current demand on existing facilities has surpassed facility capacity to provide efficient and adequate support of the activities of the existing programs. Specific deficiencies include the following:

- Inadequate laboratory, vivarium, and office space required to manage, develop, and implement mission payloads.
- Inappropriate connections between functional space types for efficient and productive life science research activities and payload processing.
- Insufficient flexibility to efficiently adapt to the changes of capacity for facility requirements posed by the scope of projected payload programs.
- Utility infrastructure operating at or beyond maximum capacity for basic payload processing activities, leaving little or no reserve for contingencies related to growth, weather, and technological advances.

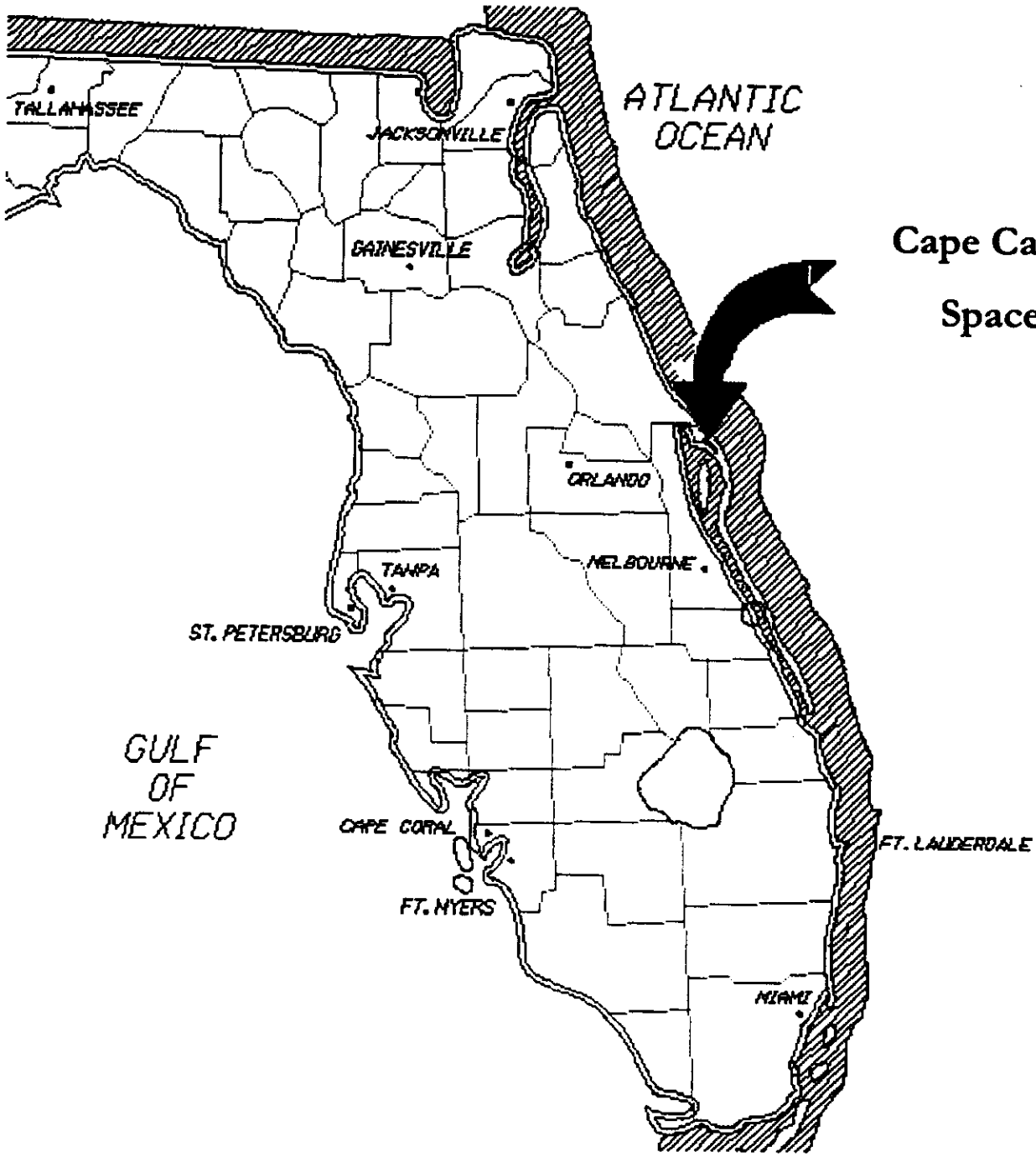


Figure 1
KSC Location Map

2.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

2.1 General

The SERPL will provide space for management and scientific services related to the efficient preparation and safe processing of payloads for life science research programs conducted in concert with the Space Transportation System (STS) for the Space Shuttle and the International Space Station. The SERPL will have space available for data archives, meeting rooms, equipment storage, and office space for management, visiting scientists and payload customers. There will be an aquatics facility, plant growth analysis facility, animal care facility and life support laboratories. The space within the facility will be organized to provide the most efficient work space for each program or entity activity (See Figure 2).

Activities proposed to be conducted within the SERPL facility will include:

- Development and implementation of technical expertise for space flight life support.
- Development and implementation of preflight and postflight processing activities of payloads for the Space Shuttle and the International Space Station.
- Development and implementation of ground controls for payload experiments.
- Monitoring of flight experiments.
- Maintenance and disposition of experimental stock materials, where appropriate for mission implementation.
- Development and implementation of payload flight hardware.
- Management of life science payload processing activities by prime contractors and NASA KSC personnel.
- Support of meeting and office needs of visiting scientists.
- Management and maintenance of the Life Science Data Archive.
- Management and implementation of general logistics for materials and equipment procurement and handling, and for personnel coordination access.
- Implementation of student education programs and outreach events.

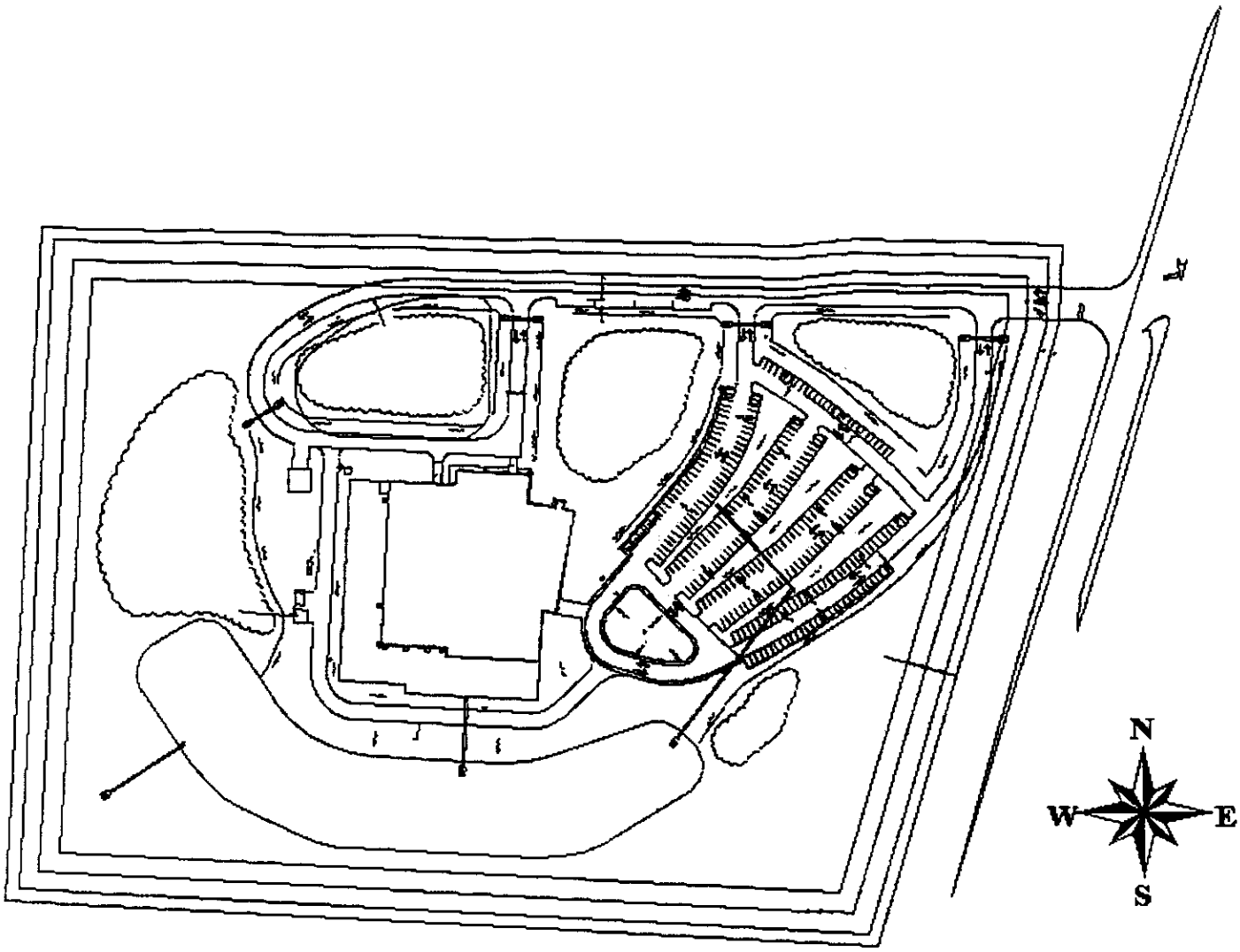


Figure 2
Proposed SERPL Layout

2.2 Proposed Action: Construct the SERPL along the west side of SR 3

The proposed action is to construct the SERPL on a 16.18 ha (40 ac) site located on the southwest corner of Kennedy Parkway and 5th Street SE (See Fig 3). The site would accommodate the SERPL building, a 200-car parking lot, and capacity for future facilities related to scientific and development research. The site also provides for the appropriate level of security for SERPL activities.

The total building area is distributed into two structures: the primary building, which houses all management and technical activities in a 2-story structure of approximately 10,596 gross square meters (gsm) (114,000 gross square feet (gsf))and the second building which houses the mechanical equipment to efficiently facilitate future growth of the SERPL.

An access road would be constructed as an extension of 5th Avenue, west of State Road 3, forming a four-way intersection from a three-way intersection. There would also be acceleration and deceleration lanes constructed southbound on State Road 3.

Another new access road would be constructed that would be used as a primary access to KSC and the KSC Visitor Complex. This access road would connect to SR 3 south of Ransom Road, continue north along the west side of the proposed action location, and would end just north of Ransom Road and south of the KSC Visitors Complex. Another project would continue this road west and north to a final connection point at Kennedy Parkway, west of the Visitor Complex. This final route has not yet been determined. Ultimately, this access road would be utilized as the primary south entrance to KSC for employees and visitors. In addition, it would provide for 24-hour access through KSC.

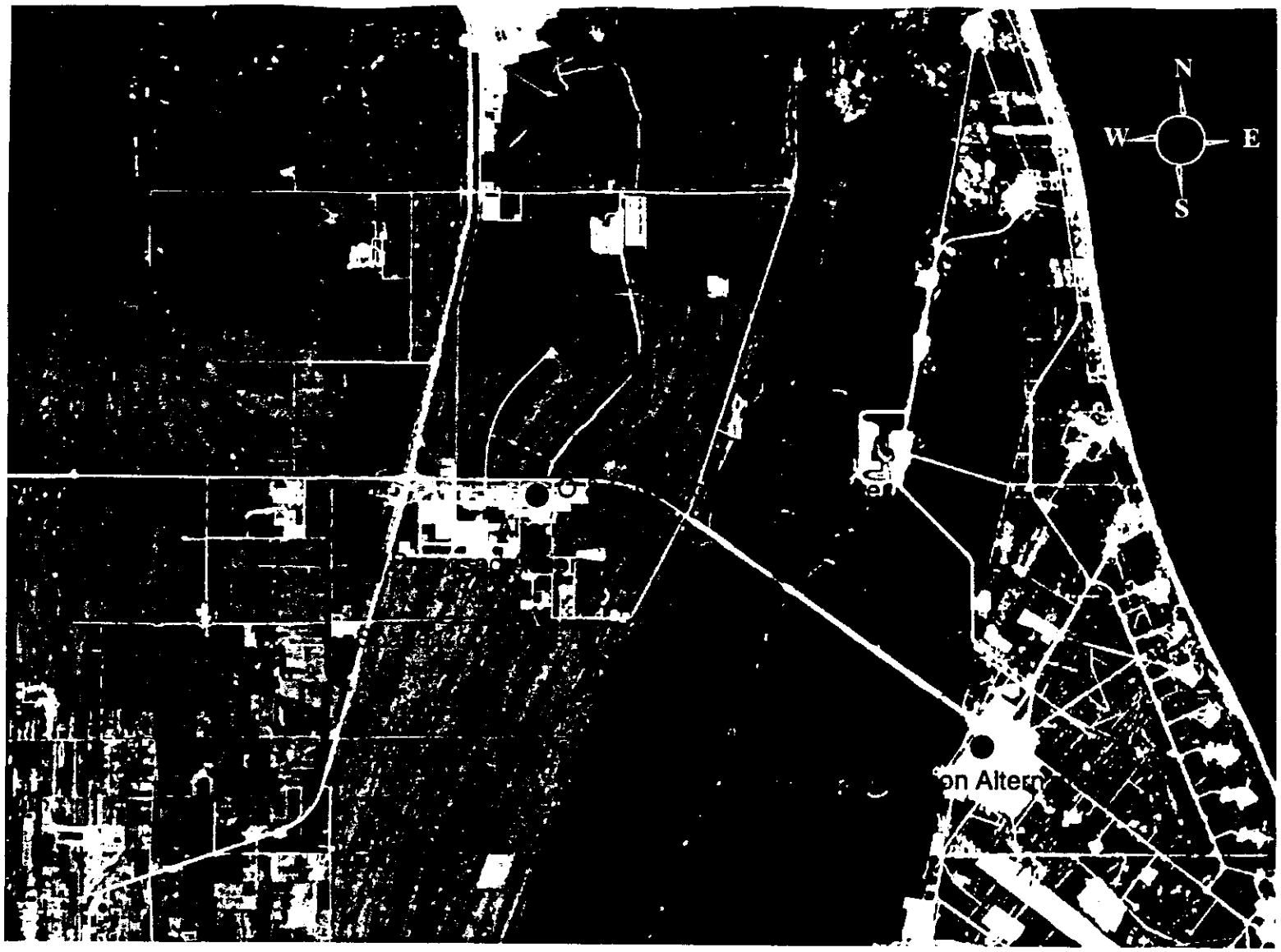


Figure 3
Alternative Locations Map

2.3 Alternative 1: Construct the SERPL along Contractors Road, south of the Heavy Equipment Area

This alternative would have the SERPL facility constructed on a 10.4 ha (25.8 ac) site located on Contractors Road, south of the Heavy Equipment Area (See Fig 3). This site accommodates the SERPL facility and necessary parking area.

2.4 Alternative 2: Construct the SERPL within the Industrial Area, south of the Headquarters Building

This alternative would have the SERPL facility constructed on an 8.9 ha (20 ac) site located directly south of the Headquarters Building within the Industrial Area of KSC (See Fig 3). This site accommodates the SERPL facility with no need for additional parking space; the parking for the SERPL would be provided by existing parking associated with the KSC Headquarters Building.

2.5 No Action

The No Action alternative would have all present and future activities continue as they are now in Hangar L and the O&C facilities (See fig 3). No new facilities would be constructed to house the preparation and processing activities for the payload and life sciences research programs.

3.0 Affected Environments

3.1 General

KSC encompasses nearly 56,000 ha (140,000 ac) on the east coast of central Florida and is bordered on the west by the Indian River Lagoon, on the southeast by the Banana River, and on the north by the Mosquito Lagoon. KSC is the primary launch and landing site for NASA's Space Shuttles with two active launch pads and is the primary eastern U.S. landing site for Space Shuttle fights. In addition to supporting the nation's space mission operations, KSC contains within its boundaries the Merritt Island National Wildlife Refuge (MINWR) and the Canaveral National Seashore (CNS), which are managed by the U.S. Fish and Wildlife Service (USFWS) and the National Park Service (NPS), respectively. This unique relationship between space flight and preservation of the environment is carefully managed to ensure that both objectives are pursued with minimal conflict with one another. The existing environment at each of the alternative sites is described in detail in the following sections.

3.2 Facilities and Infrastructure

Transportation

KSC is serviced by over 340 km (211 mi) of roadways with 263 km (163 mi) of paved roads and 77 km (48 mi) of unpaved roads. Of the five access roads onto KSC, NASA Parkway West serves as the primary access road for cargo, tourists, and personnel entering and leaving. This four-lane road originates in Titusville as State Road 405 and crosses the Indian River Lagoon, onto KSC. Once passing through the Industrial Area, the road reduces to two lanes of traffic, which crosses over the Banana River and enters the Cape Canaveral Air Force Station (CCAFS). The third point of entry onto KSC is from the south via Kennedy Parkway South, which originates on north Merritt Island as State Road 3. This road is the major north-south artery for KSC. The fourth entry point is accessible from Titusville along Beach Road, which connects to Kennedy Parkway North. The final access point is south of Oak Hill at the intersection of U.S.1 and Kennedy Parkway North.

The new by-pass road associated with the Proposed Action would provide 24-hour access for the public through KSC. Currently, the access between Merritt Island and Titusville, is closed from 6:00 pm to 6:00 am every day. This would

also affect public access to the KSC Visitor Center. SR 3, north of the new access road intersection, would be utilized by KSC badged personnel during peak entry and exit hours. Alternative 1 and 2 would not require any additional roadways.

Wastewater Treatment

The sanitary sewer system at KSC is composed of several centralized sewage treatment plants designed to treat effluent in specific areas of KSC. Sewage Treatment Plant (STP) #1 is located south of the KSC Industrial Area and serves the Unified S-Band, the Visitor Complex, and the Industrial Area. STP #4 is located in the Vehicle Assembly Building (VAB) area and serves the SLF and the VAB area. STPs #5 and #6 serve LC-39A and LC-39B, respectively. In addition to these plants, several isolated facilities utilize small package plants to treat effluent while still others use septic tanks and drain fields. STP #1 and #4 are planned to be connected to the CCAFS wastewater treatment plant. When this connection is completed, STP #1 and #4 will become lift stations and provide surge capacity as part of the CCAFS treatment system.

The Proposed Action and Alternative 1 would require a connection to STP #4 and Alternative 2 would require a connection to STP #1. The Proposed Action would require a connection from the KSC Industrial Area, Alternative 1 has access to wastewater lines located along west side of Contractors Road, and Alternative 2 has access to wastewater lines located along 2nd Ave.

Electricity

The power and lighting distribution systems for Cape Canaveral Spaceport has a total capacity of 137,000 kilovolt/amps (kVA) which is provided by the Florida Power and Light (FPL) Company. The power entering KSC is distributed from two main substations: C-5 Substation which services the LC-39 Area and the Orsino Substation which services the Industrial Area. The high voltage power is distributed from the substations by approximately 434 km (270 mi) of overhead and underground power lines to the transformers and substations of various facilities.
The Proposed Action and Alternative 1 would require a connection to the Orsino Substation and Alternative 2 would require a connection to the C-5 Substation.

Communications

The KSC Communications System provides a variety of services at KSC including: 1) conventional telephone service; 2) transmission of large volumes of test data to central collection or reduction stations; 3) transmission of timing information from operations centers to data gathering instrumentation at widely scattered locations; 4) transmission of weather and range safety data; 5) communication with satellites, Space Shuttles, and other hardware in space. The major segments are the three distribution and switching stations, in the Industrial Area (First Switch) and the VAB Area (Second and Third Switches). These three stations provide service for over 18,500 telephones on KSC.

The Proposed Action and Alternative 1 would require a connection to the First Switch and Alternative 2 would require a connection to the either the Second or Third Switch.

Potable Water

KSC's potable water is supplied by the City of Cocoa which obtains its' water from artesian wells located west of the St. Johns River in Orange County. Water enters KSC along State Road 3 from a 60 cm (24 in) water main and extends north along Kennedy Parkway South to the VAB Area. The average daily demand for water is 3.8 mLd (1 mgd). Total storage capacity at KSC is approximately 15 million L (4 million gal) in 10 aboveground storage tanks (ASTs). LC-39 has a 4 million L (1 million gal) aboveground storage tank and a 950,000 L (250,000 gal) elevated storage tank. An identical water tower is also found in the Industrial Area. Fire suppression system booster pump stations and a potable water system emergency pump are located within the Utility Annex, which receives its supply from the VAB Area aboveground storage tank.

The Proposed Action, Alternatives 1 and 2 would all require a connection to the main supply from the City of Cocoa. Existing water lines located on SR 3, Contractors Road and B Avenue can be connected, as needed.

3.3 Air Quality

The ambient air quality at KSC is predominantly influenced by daily operations such as vehicle traffic, utilities fuel combustion, standard refurbishment and maintenance operations. Air quality is also influenced to some extent

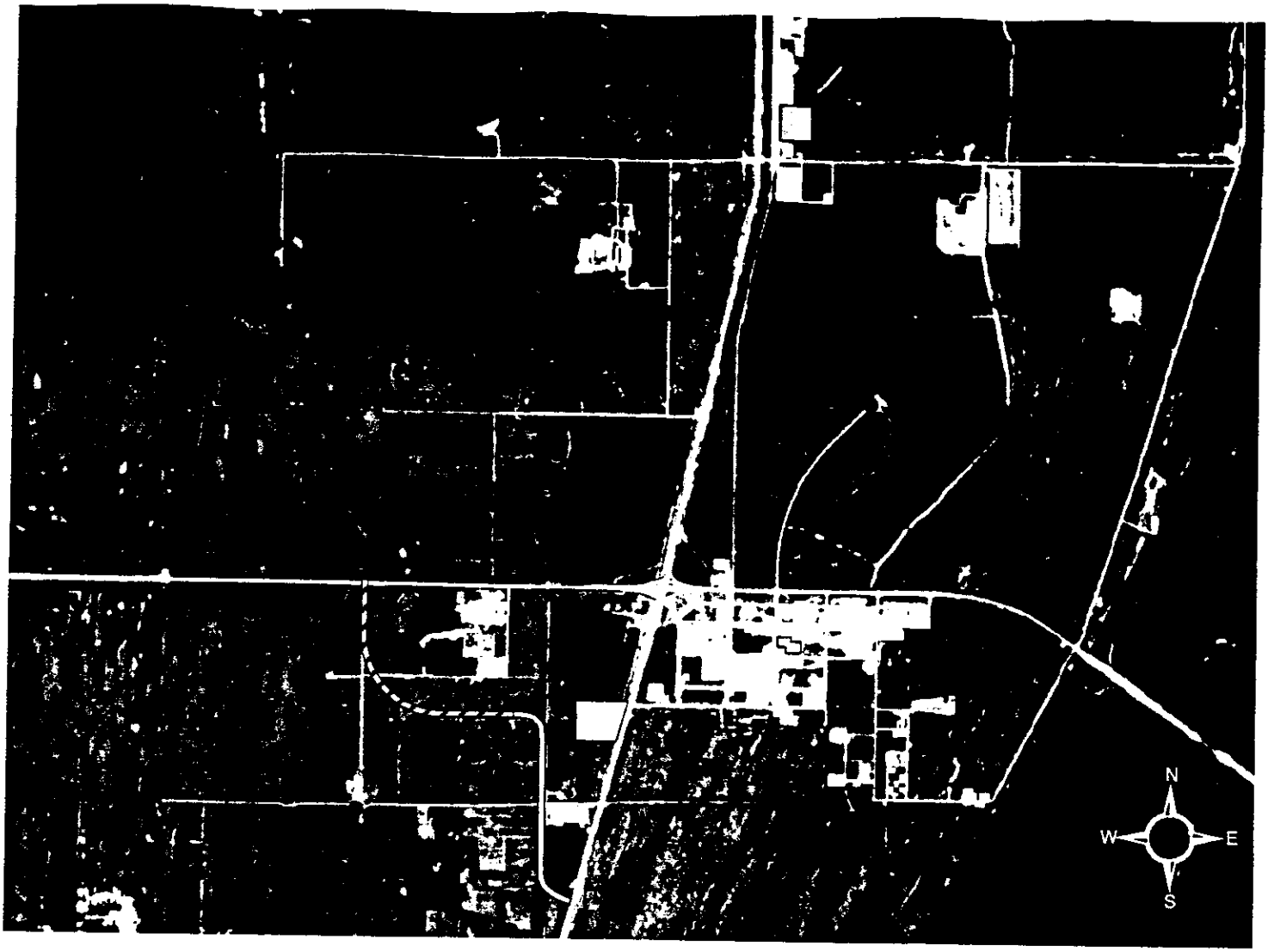
by emissions sources outside of KSC, primarily two regional power plants located within a 18.5 km (10 mi) radius of KSC. In addition to these sources, other operations occurring on an infrequent basis throughout the year also play a role in the quality of air at KSC. These include space launches and prescribed fire management practices which influence air quality as episodic events.

The ambient air quality is monitored by a Permanent Air Monitoring System (PAMS) station (See Fig 6). The PAMS station continuously monitors the concentrations of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and total inhalable (10-micron) particulates, as well as meteorological data. Currently, KSC is located within an area, which is classified as attainment with respect to the National Ambient Air Quality Standards (NAAQS) established by the Environmental Protection Agency (EPA) for all criteria pollutants (KSC 1997-A).

3.4 Biological Resources

Vegetation

Vegetation on KSC can generally be categorized into upland and wetland communities. The wetlands on KSC consist of both coastal and fresh water communities and cover approximately 15,300 ha (38,000 ac). Upland communities on KSC are characterized by well drained, acidic, sandy soils that experience only brief periods of standing water. Upland communities are highly dependent upon periodic fire for the maintenance of habitat structure and vegetation composition. Scrub and pine flatwoods are the dominant upland communities on KSC. Pine flatwoods are typically composed of an overstory of slash pine (*Pinus elliotti*) with an understory of myrtle oak (*Quercus myrtifolia*), sand live oak (*Q. geminata*) and saw palmetto (*Serenoa repens*). The scrub communities on KSC are typically composed of scrub oak species (*Q. myrtifolia, Q. geminata, Q. chapmanii*) with varying amounts of saw palmetto. Vegetation in xeric scrub is ideally about 1.5 meters (2.2 ft) in height with no notable overstory; only an occasional slash pine or cabbage palm (*Sabal palmetto*). There are species of plants found on KSC that are listed as species of special concern, threatened or endangered by the



SERPL facility site options

Future road improvements

- NADP Rain monitoring stations
- PAMS location

1 0 1 Kilometers

1 0 1 Miles

Figure 4
PAMS Station Locations

Produced by Dynamac Corporation LSSC for NASA - EPO 12/99

Florida Committee on Rare and Endangered Plants and animals (FCREPA). While there is no regulatory implication of the FCREPA listings, these species have been identified by researchers as being rare or restricted to vulnerable habitats.

The vegetation at the Proposed Action location (Figure 5) is dominated by 3.42 ha (8.45 ac) of mixed hardwood/coniferous hammock, approximately 1.8 ha (4.3 ac) of xeric oak scrub, 2.8 ha (6.9 ac) of active orange groves, 4.8 ha (11.8 ac) pine flatwoods, 0.12 ha (0.3 ac) palmetto prairie, 0.03 ha (0.1 ac) temperate/tropical hardwoods. The remaining landcover includes 0.07 ha (0.16 ac) of streams and waterways, 1.85 ha (4.6 ac) of bottomland swamps; and 0.73 ha (1.8 ac) of transmission line, other open land and roads and highways.

The vegetation contained in the road improvement corridor associated with the Proposed Action location (Figure 5) is dominated by 7.0 ha (17.5 ac) of citrus, 1.9 ha (4.7 ac) of Australian pine, 0.8 ha (2.0 ac) of temperate/tropical hardwood hammock, and 2.1 ha (5.3 ac) of pine flatwoods. The remaining landcover includes 0.6 ha (1.5 ac) of existing roadway, 0.2 ha (0.5 ac) of ditches, 0.2 ha (0.5 ac) of ruderal/open land, and 0.2 ha (0.5 ac) of mixed hardwood-conifer forest.

The vegetation at the Alternative 1 site is dominated by 8.8 ha (21.7 ac) of pine flatwoods. The remaining land is composed of 0.2 ha (0.6 ac) of cabbage palm savanna, 0.7 ha (1.9 ac) of developed governmental land, 0.3 ha (0.7 ac) of xeric oak scrub and 0.3 ha (0.9 ac) of existing roads (Figure 6).

The vegetation at the Alternative 2 site consists entirely of developed and ruderal land, specifically grassed area that is maintained by mowing (Figure 5).

Wetlands and Floodplains

The wetland communities on KSC can be characterized as freshwater herbaceous marsh and forested hammock systems, brackish water lagoons, open ocean, and managed fresh and brackish water impoundments. KSC is bordered on the western

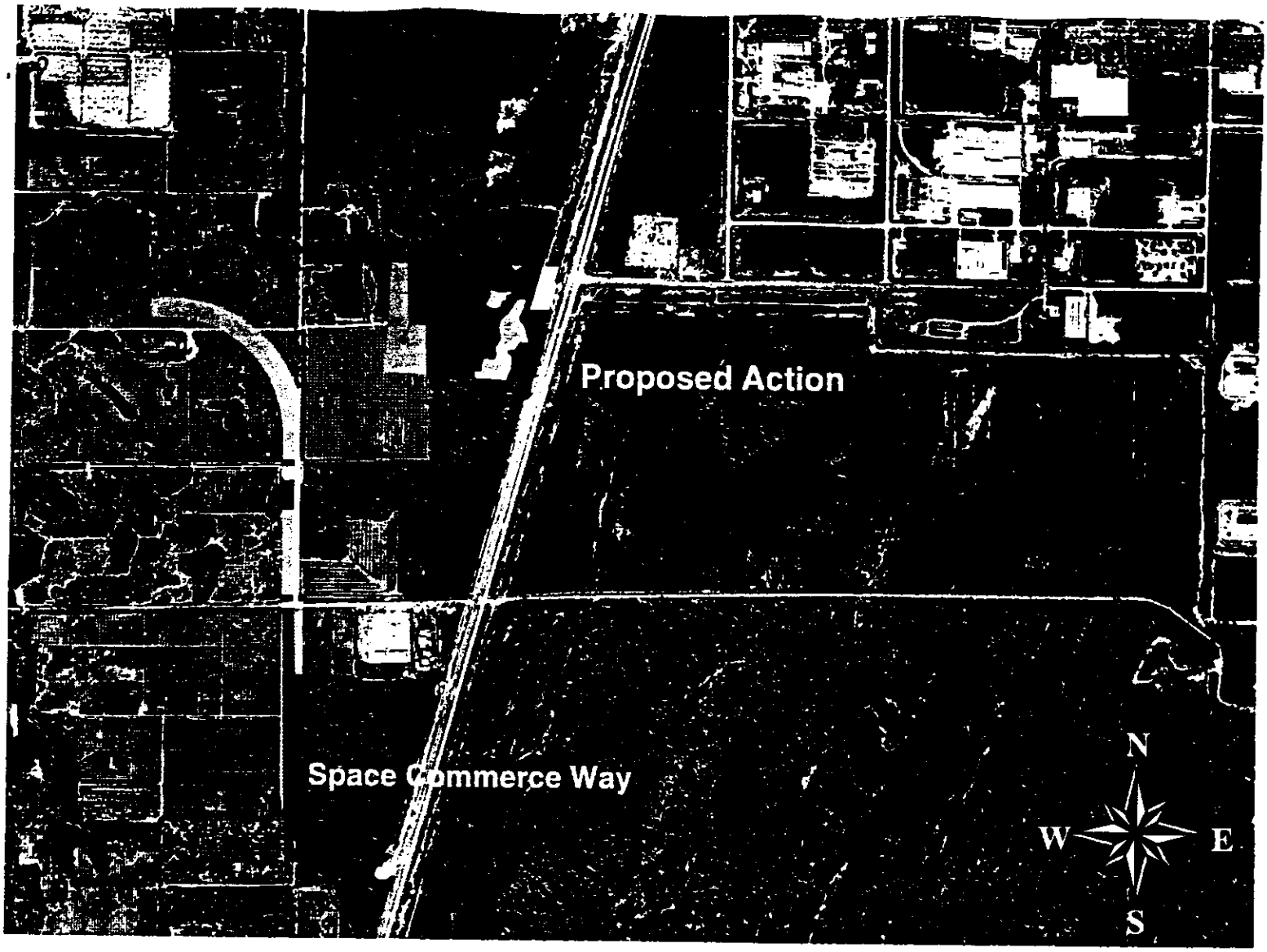


Figure 5
Landcover for Proposed Action with Road Improvements and Alternative 2

1000 0 1000 Feet

300 0 300 Meters

Landcover Key
- Australian Pine
- Citrus Groves
- Pine Flatwoods
- Roads and Highways
- Rural land in transition without positive indicators of intended use
- Streams and Waterways
- Temperate/Tropical Hardwood
- Electrical Power Transmission Lines
- Hardwood - Conifer Mixed
- Other Open Land
- Palmetto Prairies
- Stream and Lake Swamps (Bottomland)
- Streams and Waterways
- Temperate/Tropical Hardwood
- Xeric Oak

100 0 100 200 Meters

500 0 500 Feet

Landcover Key

- Cabbage Palm Savannah
- Governmental
- Pine Flatwoods
- Roads and Highways
- Rural land in transition without positive indicators of intended use
- Xeric Oak

Figure 6
Alternative 1 Landcover

edge by the Indian River Lagoon (IRL). The IRL has been nationally recognized for its quality and species diversity. The IRL is designated as a *Florida Outstanding Waterway*, an *Estuary of National Significance* and has been nominated as an *Estuary for National Research*. The IRL system throughout KSC is dominated by shallow flats of dense submerged aquatic vegetation including the seagrasses *Halodule wrightii*, *Syringodium filiforme*, and *Ruppia maritima* and the macroalga *Caulerpa prolifera* and *Gracilaria spp*. The edge of the IRL is dominated by mixed slat-tolerant grasses. Impounded salt marsh waters are found throughout KSC and are managed by FWS located on MINWR. Aquatic habitats inland on KSC include willow swamps, freshwater gramminoid marshes, and cattail marshes. The wetlands and surrounding waters of KSC support large wintering populations of waterfowl as well as transient and resident wading bird populations.

Alternatives 1 and 2 have no wetlands on site except for existing roadway ditches.

The Proposed Action location and the two Alternative locations are all outside of the 100 and 500 year floodplain (Figure 7).

Wildlife

Fish & Shellfish

The Indian River Lagoon (IRL) supports nearly 150 species of fish and supports both commercial and recreational fin fish and shellfish industries. Offshore Cape Canaveral Spaceport is one of the most productive fisheries along the east coast of Florida including significant a commercial scallop fishery (NPS 1986). A number of renewable oyster leases are also held in the waters near KSC.

Birds

KSC and the surrounding coastal areas provide habitat for over 300 bird species; nearly 90 species are breeding residents and over 100 species winter on KSC; the remaining species are transients who regularly use KSC lands and waters for brief periods of time before continuing their migration. Twelve species are listed as endangered, threatened or species of special concern by the Florida Fish & Wildlife Conservation Commission (FFWCC). Of those 12 species, 5 are listed as threatened or endangered by the USFWS and are thus under the jurisdiction of the Endangered Species Act (ESA). The most common of the federally listed species found on KSC are the Florida scrub-jay (*Aphelocoma*

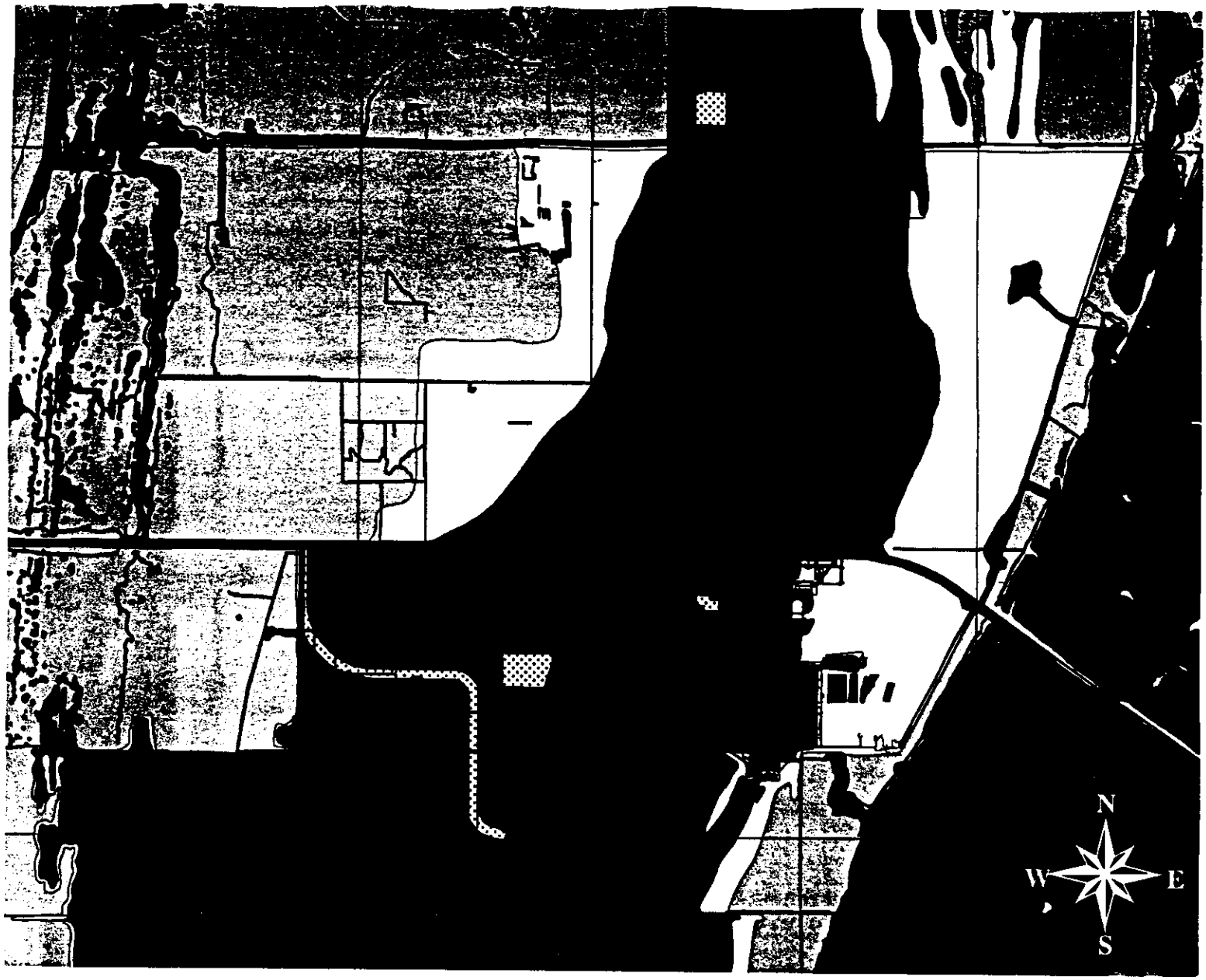


Figure 7
Floodplain Map

coerulescens coerulescens, the wood stork (*Mycteria americana*) and the southern bald eagle (*Haliaeetus leucocephalus leucocephalus*). A red-shouldered hawk was observed flying out of the hammock slated for road construction in the Proposed Action.

Mammals

More than 31 species of mammals inhabit KSC lands and waters. Typical terrestrial species include the bobcat (*Lynx rufus*), river otter (*Lutra canadensis*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), and cotton rat (*Sigmodon hispidus*). Due to the regional loss of large carnivores such as the Florida panther and red wolf; the bobcat and otter now hold the position of top mammalian predators on KSC. Additionally, a proliferation of mesopredators such as the raccoon and opossum has resulted from an imbalance of predator/prey ratios. Opportunistic species such as the cotton rat now account for a large portion of the small mammal biomass rather than habitat-specific species such as the Florida mouse and beach mouse. A large population of feral hogs is present on KSC. These hogs are actively removed by the MINWR to minimize their detrimental impacts on native communities. Two mammal species common in the KSC waters of the IRL are the Atlantic bottlenosed dolphin (*Tursiops truncatus*) and the West Indian manatee (*Trichechus manatus*). The manatee is a federally listed endangered species and both the manatee and dolphin are protected under the Marine Mammal Protection Act (MMPA).

Herpetofauna

Fifty-two species of reptiles (12 federally or state protected) and 16 species of amphibians (one species of special concern) potentially occupy the KSC region. Relatively common species on KSC include the American alligator (*Alligator mississippiensis*), yellow rat snake (*Elaphe obsoleta*), and a variety of frog species. An important reptile resident of the Space Center is the gopher tortoise (*Gopherus polyphemus*), a State listed threatened species. The gopher tortoise excavates burrows which are used by many other species. For this reason, the tortoise is considered a keystone species which means the existence of other species are dependent on the existence of gopher tortoise. Marine turtle species (all federally listed) use Cape Canaveral Spaceport beaches for nesting during the summer months and can be found in the offshore waters year round.

Biodiversity

The potential impacts of the SERPL alternatives to wildlife species deemed locally significant to KSC (Breininger et al,

1994) can be found in Appendix A. This information is based on the habitats impacted by the Proposed and Alternative Actions. The table depicts wildlife species that may or may not be protected by state or federal guidelines, but have been deemed important by researchers as notable components of the biodiversity on KSC.

3.5 Threatened & Endangered Species

At present, there are over 19 federal and state laws in effect that deal directly with the conservation and preservation of flora and fauna in Florida. The primary objectives of these laws are to establish the listing and delisting processes for endangered and threatened species, to maintain data on current populations of species, to identify and maintain critical habitat, and to protect those species, which have been identified as threatened or endangered.

There are 27 state or federally listed wildlife species that regularly use the lands or waters of KSC (Table 3-1).

Scrub-jays were observed adjacent to the Proposed Action location and are documented across SR 3. Suitable scrub-jay habitat exists on the east side of this site (1.4 ha, 3.4 ac). Two active gopher tortoise burrows were documented during the biological survey of the site, one along the power corridor and another within the pine flatwoods on site. Potentially suitable habitat for tortoises is present all along the power corridor, in the oak scrub, the pine flatwoods, and citrus groves, totaling 7 ha (17.3 ac). During the biological survey, one researcher saw what was believed to be an indigo snake moving from the citrus groves into an adjacent ditch, although the siting was not thoroughly documented. Suitable habitat exists throughout the entire 43-acre building site and proposed road corridor. This area is probably occupied by at least one indigo, and very likely contributes to a number of indigo home ranges. Wading birds were noted to utilize the drainage ditches located on the site.

The northern portion of the Alternative 1 location contains approximately 0.3 ha (0.7 ac) of suitable scrub jay habitat and two scrub jays were observed utilizing this portion of the site. This site is adjacent to high quality scrub habitat to the northeast that is occupied by scrub-jays.

Table 3-1
State and Federally Listed Species within Habitats at Alternative Locations

Scientific Name	Common Name	Level of Protection	Proposed Action	Alt 1	Alt 2
Amphibians and Reptiles					
Rana capito	Gopher frog	State	X	X	
Alligator mississippiensis	American alligator	Federal	X	X	X
Caretta caretta	Atlantic loggerhead turtle	Federal			
Chelonia mydas	Atlantic green turtle	Federal			
Dermochelys coriacea	Leatherback turtle	Federal			
Gopherus polyphemus	Gopher tortoise	State	X	X	
Drymarchon corais couperi	Eastern indigo snake	Federal	X	X	
Nerodia fasciata taeniata	Atlantic salt marsh snake	Federal			
Pituophis melanoleucus mugitus	Florida pine snake	State	X	X	
Birds					
Pelecanus occidentalis	Brown pelican	State			
Egretta thula	Snowy egret		x		
Egretta caerulea	Little blue heron	State	X		
Egretta tricolor	Tricolored heron	State	X		
Egretta refescens	Reddish egret	State			
Eudocimus albus	White ibis	State	X		
Ajaia ajaja	Roseate spoonbill	State			
Mycteria americana	Wood stork	Federal	X		
Haliaeetus leucocephalus	Bald eagle	Federal			
Falco peregrinus tundrius	Arctic peregrine falcon	State			
Falco sparverius paulus	Southeastern American kestrel	State	X		
Charadrius melodus	Piping plover	Federal			
Sterna antillarum	Least term	State			
Rynchops niger	Black skimmer	State			
Aphelocoma coerulescens coerulescens	Florida scrub-jay	Federal	X	X	
Mammals					
Peromyscus polionotus niveiventris	Southeastern beach mouse	Federal			
Podomys floridanus	Florida mouse	State	X	X	
Trichechus manatus	West Indian manatee	Federal			

The pines in this area are very large and mature and would provide excellent habitat for many species of owls, woodpeckers and hawks. The edge of the entire site is suitable for gopher tortoises and tortoises have been observed along the firebreak on occasion. However, none were observed during the biological survey. Although the size of this site is too small to support an indigo population, its proximity to other suitable habitat makes it likely that the area is incorporated into at least one indigo home range.

No threatened or endangered species were noted on the Alternative 2 location. Cattle egrets and grackles were the only species utilizing this site during the biological survey.

3.6 Cultural Resources

Sites containing potential archeological and/or historical resources on KSC are protected under the National Historical Preservation Act (NHPA), which requires that every Federal Agency "take into account" how each undertaking could affect historic sites. The areas proposed for construction in this study have been previously mapped by NASA to indicate their potential for containing historical artifacts (AC 1992). Areas that have low potential for historical artifacts may not require additional Phase I or II archaeological surveys.

The Proposed Action, Alternatives 1 and 2 are all in Low Potential areas of archaeological significance. In addition, there are no known historic or archaeological sites within these sites.

3.7 Geology and Soils

KSC is located on Peninsular Florida, which gradually rose above a much larger feature called the Florida Plateau. Four distinct geologic units are characteristic of the coastal area of East-Central Florida and lie beneath KSC. In descending order these are Pleistocene and Recent Age sands with interbedded shell layers; Upper Miocene and Pliocene silty or clayey sands; Central and Lower Miocene compacted silts and clays; and Eocene limestones. During the construction phase of facilities for the Manned Lunar Landing Program at Merritt Island and Cape Canaveral, Florida, the Army Corps of Engineers (COE) documented numerous geological reports with emphasis on general and detailed foundation information. These reports can be found in the KSC Technical Documents Library.

The soils on the Proposed Action location are composed of Immokalee sand, Copeland-Bradenton-Wabasso complex and Myakka sand. Figure 8 shows the soils associated with the Proposed Action location including the road improvements associated with this alternative.

The road improvements that are associated with the Proposed Action include improvements to Range Road and a new access road. The 100'wide corridor along the length of Range Rd is composed of the following soils:

Immokalee sand
Wabasso sand
Copeland-Bradenton-Wabasso complex
Bradenton fine sand - limestone substratum
Chobee mucky loam fine sands - depressional
Anclote sand - depressional
Myakka sand

Soils in the area designated for access road construction between existing Range Rd. and Kennedy parkway is composed of Immokalee sand, Copeland-Brandenton-Wabassocomplex, Wabasso sand, and Myakka sand.

The soils at the Alternative 1 location (Figure 9) are composed of Immokalee sand, Basinger sand, and Wabasso sand.

The soils on the Alternative 2 location (Figure 8) are composed of Immokalee sand and Anclote sand.

3.8 Noise

Noise generated at KSC originates from six different sources: 1) Orbiter reentry sonic booms, 2) launches, 3) aircraft movements, 4) industrial operations, 5) construction, and 6) traffic noises. Noise generated above ambient levels by these sources has the potential to adversely affect both wildlife and humans. Some typical values for noise levels are shown on Tables 3-2 and 3-3 for activities occurring at construction sites and for activities conducted routinely at KSC. The effects of noise on wildlife have been studied to an extent at Cape Canveral Spaceport during the launch of spacecraft (KSC 1981 and Breininger 1990). These studies have shown that besides an initial startle response to launches, birds and other wildlife return to their normal activities soon afterward and show no adverse affects. Other studies conducted on wading bird colonies subjected to military overflights (500 feet of altitude) with noise levels up to 100 decibels (dBA)

Figure 8
Soils for Proposed Action with Road Improvements and Alternative 2

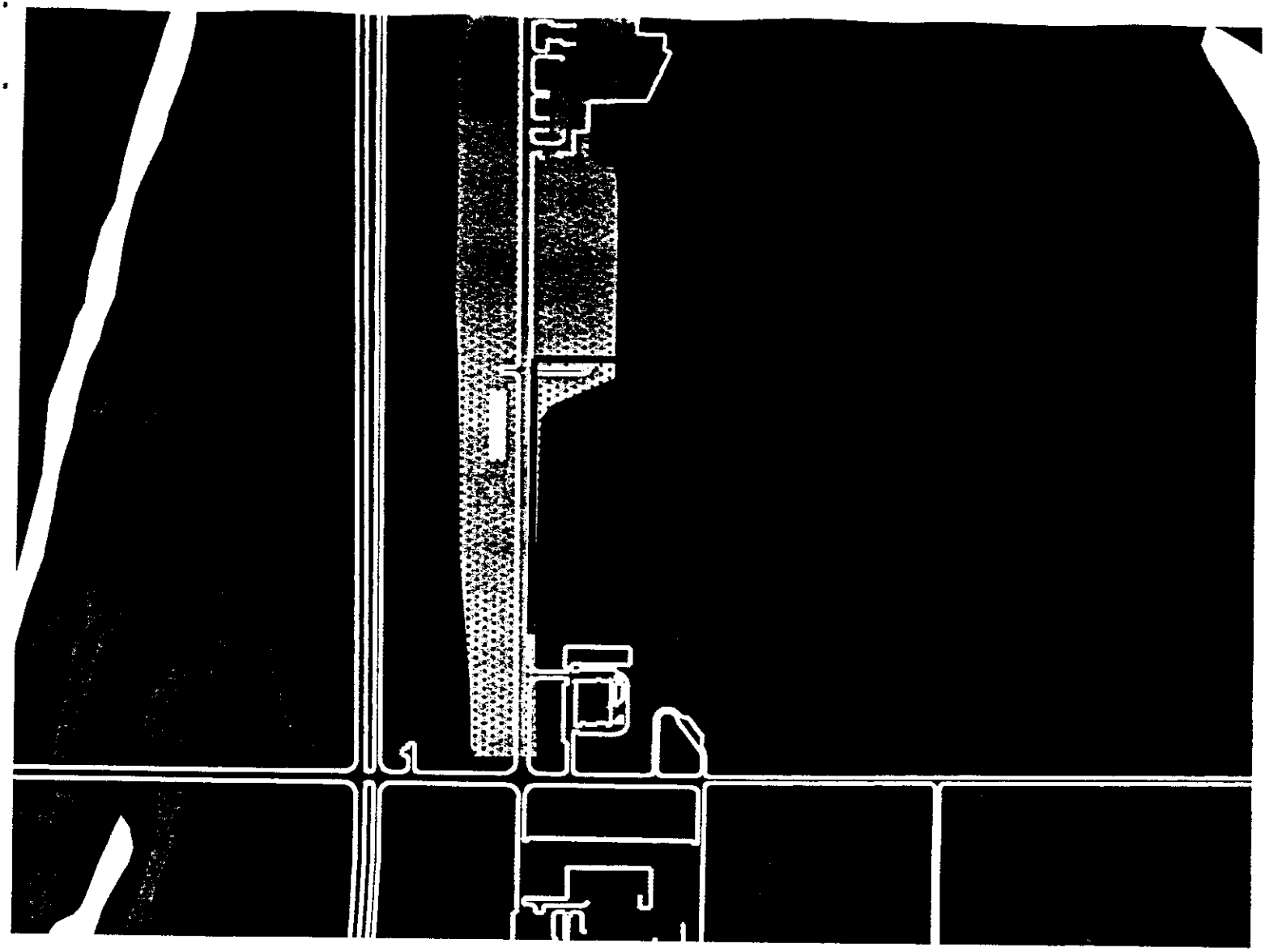


Figure 9
Soils for Alternative 1

Table 3-2
Construction Noise on KSC

SOURCE	NOISE LEVEL (Peak)	DISTANCE FROM SOURCE[a] 50 ft	100 ft	200 ft	400 ft
Construction					
Heavy Trucks	95	84-89	78-83	72-77	66-71
Pickup Trucks	92	72	66	60	54
Dump Trucks	108	88	82	76	70
Concrete Mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Paver	109	80-89	74-83	68-77	60-71
Generator	96	76	70	64	58
Shovel	111	91	85	79	73
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Caterpillar	103	88	82	76	70
Dragline	105	85	79	73	67
Shovel	110	91-107	85-101	79-95	73-95
Dredging	89	79	73	66	77
Pile Driver	105	95	89	83	77
Ditcher	104	99	93	87	81
Fork Lift	100	95	89	83	77
Vehicles					
Diesel Train	98	80-88	74-82	68-76	62-70
Mack Truck	91	84	78	72	66
Bus	97	82	76	70	54
Compact Auto	90	75-80	69-74	63-68	57-62
Passenger Auto	85	69-76	63-70	57-64	51-68
Motorcycle	110	82	76	70	64

[a] Assume 6 dBA decrease for every doubling of distance.
Ref: Golden 1980.

Table 3-3
Measured Noise on KSC

Source	Peak	Remarks
Re-Entry Sonic Boom [1]		
Orbiter		101 N/m2 max. (2.1 psf)
SRB casing		96 to 144 N/m2 (2 to 3 psf)
External tank		96 to 192 N/m2 (2 to 4 psf)
Launch Noise		
Titan IIIC	94	21 Oct 1965 (9,388 m)
Saturn I	89	Avg. of 3 (9,034 m)
Saturn V	91	15 Apr 1969 (9,384 m)
Atlas	96	Comstar (4,816 m)
Space Shuttle [1]	90	1.4 dBA Down From Saturn V (9,384 m)
Aircraft		
F4 Jet	107	18 km From Ground Zero
F4 Jet	158	Calculated at Ground Zero
NASA Gulfstream	109	Takeoff (Marker 14)
NASA Gulfstream	100	Landing (Marker 14)
Industrial Activities		
Complex 39A	78	Transformers
LEFT	92	Hydraulic Charger Unit
Machine Shop	112	Base Support Building M6-486
Computer Room	88	VAB - Room 2K11
Snack Bar	60	CIF - Room 154
Laboratories	58	CIF - Rooms 139 and 282
Elevator	62	Central Instrumentation Fac.
VAB High Bay	108	Welding, Cutting, etc.
VAB High Bay	116	Chipping
Hangar AE	77	Room 125 During Test
Headquarters Office	75	Room 2637 and Printers
O&C Office	57	Room 2063
Mobile Launcher Platform	94	Main Pump Operating
Mobile Launcher Platform	100	2 Pumps Operating 5K Load
Industrial Area	66	15 m From Traffic Light
Undisturbed Areas		
Seashore	69	Medium Waves (Nice Day)
Riverbank	48	Light Gusts (No Traffic)
150 m Tower	64	Light Gusts of Wind
[1] Estimated		

Ref: KSC 1978

observed no productivity limiting responses and only a short-term interruption of their daily routine (Black 1984). Permissible noise exposure limits for humans are established by the Occupational Safety and Health Administration (OSHA). The 8-hour time weighted average noise level on KSC is appreciably lower than the OSHA recommended level of 85 dBA.

3.9 Surface Water Quality

The surface waters in and surrounding KSC may best be described as shallow estuarine lagoons and include portions of the Indian River Lagoon, the Banana River, Mosquito Lagoon, and Banana Creek. The area of Mosquito Lagoon within the KSC boundary and the northernmost portion of the Indian River Lagoon, north of the Jay Jay Railway spur crossing, are designated by the State as Class II, Shellfish Propagation and Harvesting. All other surface waters at KSC have been designated as Class III, Recreation and Fish and Wildlife Propagation. All surface waters adjacent to and within the MINWR have the distinction of being designated as Outstanding Florida Waters (OFW) as required by Florida Statutes for waters within National Wildlife Refuges.

Several agencies including NASA, the USFWS, and Brevard County maintain water quality monitoring stations at surface water sites within and around KSC. The data collected is used for long-term trend analysis to support land use planning and resource management. Surface water quality at KSC is generally good, with the best areas of water quality being adjacent to undeveloped areas of the lagoon, such as Mosquito Lagoon, and the northern most portions of the Indian River Lagoon and Banana River.

There are no large bodies of surface water associated with any of the sites assessed for this project.

3.10 Groundwater Quality

The State of Florida, through legislation, has created four categories to rate the quality of groundwater in a particular area. The criteria for these categories is based upon the degree of protection that should be afforded to that groundwater source, with Class G-I the more stringent and Class G-IV the lesser. The groundwater at KSC is classified as Class G-II, which means that the groundwater is a potential potable water source and generally has a total dissolved solids content of less than 10,000 mg/L. The subsurface of KSC is comprised of the Surficial Aquifer, the Intermediate Aquifer, and the Floridan Aquifer. Recharge to the Surficial Aquifer system is primarily due to

the infiltration of precipitation; however, the quality of water in the aquifer beneath KSC is influenced by the intrusion of saline and brackish surface waters from the Atlantic Ocean and surrounding lagoon systems. This is evident by the high mineral content, principally chlorides, that has been observed in groundwater samples collected during various KSC surveys. The groundwater quality for the Intermediate and Floridan Aquifers at KSC are shown on Table 3-4. The groundwater recharge areas for the Proposed Action location and the Alternative locations is shown in Figure 10.

The Surficial Aquifer in the area of the Proposed Action site, Alternatives 1 and 2 is called the West Plain Subaquifer and is in a region considered to be fair to poor in terms of its ability to recharge the underlying aquifer systems. The waters of this aquifer system are predominately fresh; however, due to intrusion from nearby saline waters, some areas may exhibit high chloride as well as high total dissolved solids concentrations.

3.11 Socioeconomics

The KSC workforce is comprised of approximately 13,213 personnel, including contractor, construction, tenant, and permanent civil service employees (KSC 1999). Approximately 50 percent of the personnel have positions directly related to the Space Shuttle and payload processing operations. The remaining work force is employed in ground and base support, unmanned launch programs, crew training, engineering, and administrative positions. Approximately 53 percent of the personnel at KSC are stationed in the VAB Area, while 39 percent are located in the Industrial Area. The remaining work force is stationed at various outlying facilities at Cape Canaveral Spaceport. The personnel and equipment that are proposed for relocation to the new SERPL facility are presently housed in Hangar L and the O&C facility. Additional personnel proposed to be housed in the SERPL facility, will support Space Station activities. Visiting scientists who require laboratory space to conduct their research will also be using the SERPL facility on a temporary basis.

3.12 Land Use

KSC comprises approximately 56,600 ha (140,000 ac) of which nearly 95 percent is undeveloped area including uplands, wetlands, mosquito control impoundments, and open water areas. KSC is unique in that the MINWR and the CNS lie within its

Table 3-4
Groundwater Recharge Areas on KSC

			INTERMEDIATE AQUIFIER SYSTEM			FLORIDAN AQUIFER SYSTEM		
Parameter	**Drinking Water Stds.**		**Mean Conc.**	**Minimum Conc.**	**Maximum Conc.**	**Mean Conc.**	**Minimum Conc.**	**Maximum Conc.**
INORGANICS								
Chlorides	(S)	250.000	10134.000	1340.000	28400.00	1882.00	1189.00	3062.00
Manganese	(S)	0.050	<0.050	<0.050	<0.05			
Nitrate	(P)	10.000	0.020	<0.010	6.00			
Sodium	(P)	160.000	5360.000	550.000	10500.00	950.00	614.00	1531.00
Sulfate	(S)	250.000	695.000	10.000	1900	282.00	251.00	320.00
PHYSICAL PARAMETER								
TDS	(S)	250.000	15163.000	2870.000	2700.00	3778.00	2326.00	7823.00
pH	(S)	6.500	7.620	7.020	8.31	7.45	7.18	7.15
Alkalinity			189.000	170.000	200.00	810.00	133.00	381.00
TRACE METALS								
Arsenic	(P)	0.050	0.060	<0.050	0.100			
Barium	(P)	1.000	<1.000	<1.000	<1.000			
Cadmium	(P)	0.010	0.020	<0.010	<0.050			
Chromium	(P)	0.050	<0.050	<0.050	<0.050			
Copper	(S)	1.000	<1.000	<1.000	<1.000			
Iron	(S)	0.300	1.720	<0.030	4.060	0.11	0.10	0.13
Lead	(P)	0.050	<0.050	<0.050	<0.050			
Mercury	(P)	0.002	<0.002	<0.002	<0.002			
Selenium	(P)	0.010	0.060	0.200	<0.010			
Silver	(P)	0.050	<0.050	<0.050	<0.050			
Zinc	(S)	5.000	0.070	<0.020	0.330			
Gross Alpha (pCi/l)	(P)	15.000	11.500	2.60.000	21.000			
Fecal Coliform (n/.11)	(P)	1.000	<12.000	<10.000	20.000			
ALL CONCENTRATIONS EXPRESSED IN mg/l UNLESS OTHERWISE SPECIFIED.								

Source: Ref 4-6

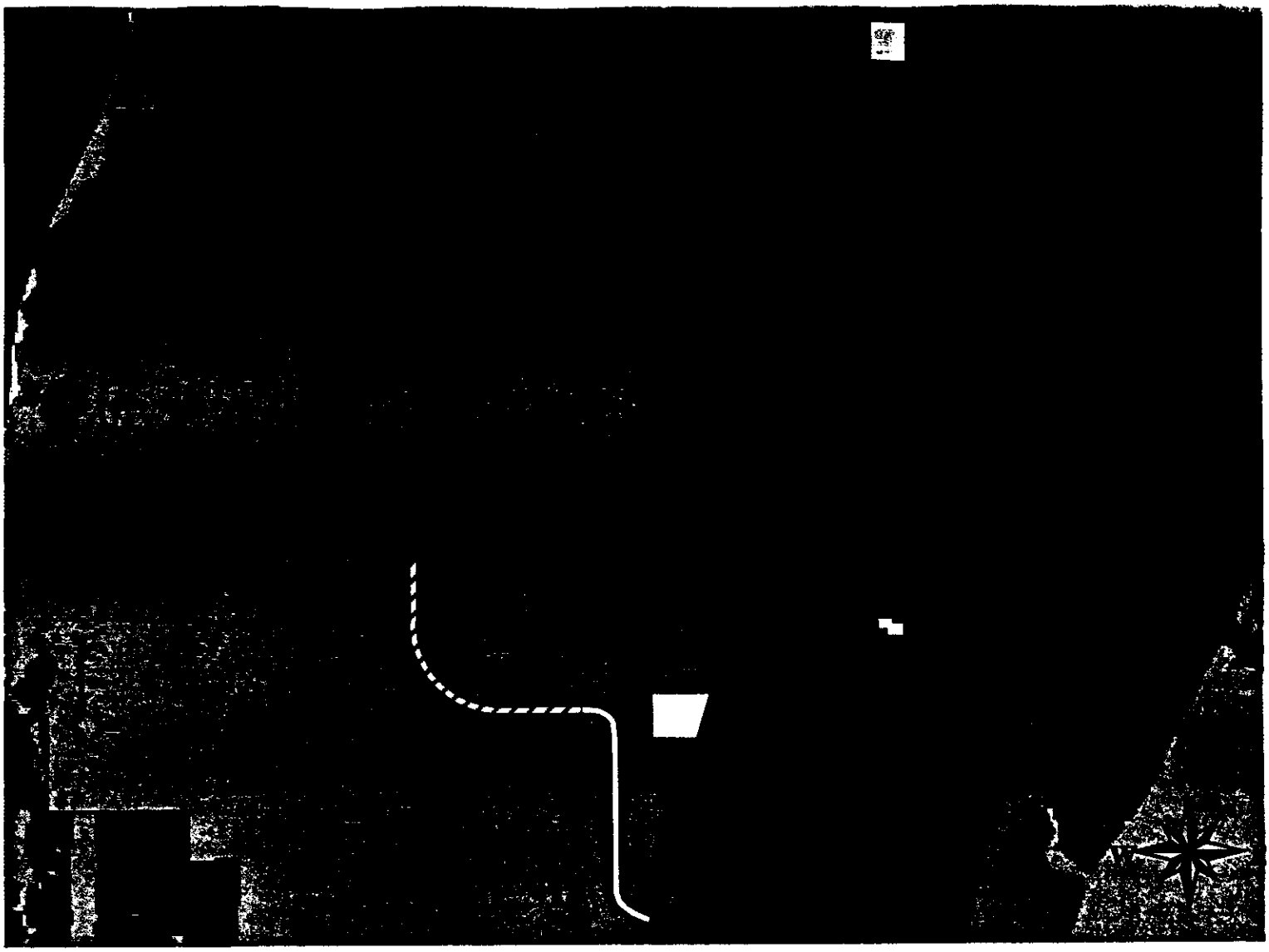


Figure 10
Groundwater Recharge Map

boundaries and are managed for NASA by the USFWS and the NPS, respectively. These agencies exercise management control over agricultural, recreational, and environmental programs within the MINWR and the CNS.

NASA Manages nearly 6000 acres of facilities and rights-of-way. Approximately 4300 acres of the 6000 acres are around operational facilities that have been removed from USFWS fire management units. The remaining undeveloped operational areas are dedicated safety zones around existing facilities or are held in reserve for planned and future expansion. The developed operational areas within KSC are dominated by the VAB Area, the Industrial Area, and the SLF. These facilities account for more than 70 percent of the NASA operational area.

The Proposed Action location is currently undeveloped and is classified as Refuge land as part of the MINWR. Implementation of this action would require the removal of the area occupied by the site from the Refuge. Alternative 1 is located in an undisturbed area along the industrial development of Contractor's Road. Alternative 2 is entirely within the previously developed section of the KSC Industrial Area.

4.0 Environmental Consequences and Mitigation

4.1 Summary of Relevant Issues and Status of Issues

Impacts resulting from the implementation of this project were identified and then classified in one of the five following categories:

- Not Applicable (N/A) - those activities not related to the site specific or global environment
- None - those areas in which no impacts are expected
- Minimal - those areas in which the impacts are not expected to be measurable or are too small to cause any discernable degradation to the environment
- Minor - those impacts which will be measurable but are within the capacity of the impacted system to absorb the change, or can be compensated for, so that the impact is not substantial
- Major - those environmental impacts which individually or cumulatively could be substantial

Impacts of the construction and operation at each of the alternative sites vary from none to minor upon the environmental issues evaluated. Results of the analyses are summarized in Table 4-1, which shows the impacts to each media for each alternative.

This matrix can be used to review the overall impacts of implementation of this project for each site alternative. The following discussion provides the detail of the scope and type of these impacts. This section is organized by alternative so that the overall impacts of each alternative can be seen as a whole.

Table 4-1
Issues Matrix

Issues		Proposed Action	Alt. 1	Alt. 2	No Action
Facilities and Infrastructure					
Transportation	C	Minimal	None	None	None
	O	Minor	None	None	None
Utilities	C	Minimal	Minimal	Minimal	None
	O	None	None	None	None
Air Quality	C	Minor	Minimal	None	None
	O	None	None	None	None
Biological Resources	C	Minor	Minor	None	None
	O	None	None	None	None
Threatened & Endanagered Species	C	Minimal	Minor	None	None
	O	Minimal	None	None	None
Cultural Resources	C	None	None	None	None
	O	None	None	None	None
Geology	C	None	None	None	None
	O	None	None	None	None
Noise	C	Minor	Minor	None	None
	O	None	None	None	None
Surface Water Quality	C	Minimal	Minimal	None	None
	O	None	None	None	None
Groundwater Quality	C	None	None	None	None
	O	None	None	None	None
Socioeconomics	C	Minimal	Minimal	Minimal	None
	O	Minimal	None	None	None
Land Use	C	Minor	None	None	None
	O	None	None	None	None

Key to Categories:

N/A: The issue has no relevance to the site environment.
None: There are no impacts expected.
Minimal: The impacts are not expected to be measureable or are too small to cause any discernable degredation to the environment.
Minor: Those impacts which are measureable, but are within the capacity of the impacted system to absorb the change, or the impacts can be compensated for, so that the impact is not substantial.
Major: Those environmental impacts which individually or cumulatively could be substantial.
C: Construction
O: Operation

4.2 Proposed Action

4.2.1 Facilities and Infrastructure

Transportation

Construction

The construction activities of the SERPL and the new access road along the west side of SR 3 is expected to have minor impacts to transportation routes within KSC. Increased construction traffic would occur during normal working hours and may cause some traffic delays. However, the capacity of all affected roads is not expected to be exceeded by this increase in vehicles.

Operation

The operation of the SERPL is expected to produce only minimal impacts to roads on KSC as the number of vehicles entering the Center is not expected to increase. There would be a shift of traffic currently associated with Hangar L on CCAFS and the O&C Building in the KSC Industrial Area. However, as this is all internal to the Cape Canaveral Spaceport, this is not expected to cause any traffic delays. The new access road to the SERPL is expected to have minimal impacts to transportation routes to the SERPL and on KSC.

The new by-pass road would provide 24-hour access between north Merritt Island and the city of Titusville. This is a new condition and is expected to affect traffic patterns between these areas. Currently, between the hours of 6:00 pm and 6:00 am, all traffic between these areas must use SR 3, SR 520 and US-1. These roads would be relieved of this traffic during the nighttime hours upon the completion of this new by-pass road. This is considered a positive effect of minor to major extent. It should be noted, however, that this project alone would not result in a complete by-pass road, therefore, it would not produce these impacts. The complete access through KSC will not occur until the second phase of the road is complete. The exact date and route of this second phase has not yet been finalized. The impacts of the completed road will again be addressed at that time.

Utilities

Construction

The construction of the SERPL at the Proposed Action location would require connections to wastewater, electrical, communication, and potable water utilities. There are no wastewater or communication connections in the vicinity of the Proposed Action location. There are

overhead power lines that could provide electricity to the SERPL and there is and existing potable water line on the east side of SR 3. The construction at this site is expected to present minimal impacts to these utilities.

Operation
The operation of the SERPL at the Proposed Action location is expected to have no impacts to the utilities.

4.2.2 Air Quality

Construction
The site preparation and construction of the SERPL facility at the Proposed Action location would produce minor impacts to the surrounding air quality. The clearing of land and other construction activities would generate airborne particulates from earth moving as well as hydrocarbon exhaust from heavy equipment. Such activities are expected to be small in scope and of short duration. BMP's would also be employed to mitigate for emissions due to earth movement. These BMP's include water spraying, placement of hay bales, and other forms of dust control.

Operation
The operation of the SERPL at the Proposed Action location is not expected to have any impacts to the surrounding air quality.

4.2.3 Biological Resources

Vegetation

Construction
Construction activities at the 43 acre site would result in the removal of some area of several biological community types available on the Space Center as follows:

Community Type	Hectares	Acres
mixed hardwood/coniferous hammock	3.42	8.45
xeric oak scrub	1.8	4.3
orange groves	2.8	6.9
pine flatwoods	4.8	11.8
palmetto prairie	0.12	0.3
temperate/tropical hardwoods	0.03	0.1
streams and waterways	0.07	0.16
Bottomland swamps	1.85	4.6.
Transmission line, open land & roads	0.73	1.8

Impacts to the area would be minimized by selective clearing for a facility design that maintains as much existing, native vegetation as possible. The construction at the Proposed Action location is expected to have minor impacts to these vegetation types on KSC as a whole.

Impacts to vegetation would occur from the construction and improvements of roads to access the facility. Natural communities impacted by road construction include:

Community Type	Hectares	Acres
Australian pine	1.9	4.7
citrus groves	7.1	17.5
temperate/tropical hardwood	0.8	2.0
pine flatwoods	2.1	5.3
existing roadway	0.6	1.5
streams and waterways	0.2	0.5
ruderal/open land	0.2	0.5
Mixed hardwood-conifer forest	0.2	0.5

The vegetation at the proposed SERPL building site and associated road improvements is comprised of a variety of community types that are also well represented throughout the Kennedy Space Center. The proposed action would remove 11 ha (24 ac) of active citrus groves, which represents less than .005 percent of all groves on the center. Similarly, the action would remove 6 ha (17 ac) of pine flatwoods representing approximately 0.002 percent of the total pine flatwoods communities on the Center and 1.84 ha (4.56 ac) of bottomland swamps, representing 0.003 percent of the Center's bottomland swamps. The most significant removal would be of the mixed hardwood coniferous community, 3.4 ha (8.9 ac), which represents 0.01 percent of the entire community on KSC. All other vegetation impacted by the SERPL construction represents only a very small fraction of that type of vegetation.

Operation

No impacts to vegetation are expected from the operation of the SERPL. Exceptions could be in the planting of non-native or inappropriate vegetation species that could invade and degrade surrounding habitats. Also, removal of this site from the refuge management program may influence the effectiveness of fire management in adjacent habitats due to an increase in edge effects. Additionally, operations occurring in the SERPL could limit the ability to use prescribed burning in adjacent habitats, particularly for particulate concerns in clean rooms or other similar facilities within the SERPL. Facility design whould

incorporate technology to allow prescribed burning in the nearby landscape.
Operations of the SERPL would be indirectly affected by the new roadways. Edge vegetation tends to become invaded with weedy or exotic species and is difficult to manage with natural fire regimes leading to a change in vegetation structure. Maintenance requirements would include planting grass, creating ditches and regular mowing. All these activities would produce changes the natural community composition and structure.

Wetlands and Floodplains

Construction
Construction of the SERPL and the road improvements would remove approximately 3.25 ha (8.26 ac) of wetlands consisting of hardwood hammock, bottomland swamp and streams and waterways. This construction impact is moderate to minimal in the areas surrounding the orange groves and ditches; however, impacts to the hammock communities are considered greater because of their rareness on KSC and sensitivity to disturbance.

Operation
There are no expected impacts to wetlands or floodplains due to operational activities of the SERPL at the Proposed Action location.

Wildlife

The potential impacts to wildlife by the SERPL construction and operation for each alternative can be found in Table 4-2. This information is based on the habitats removed by the proposed and alternative actions, typical construction activities for clearing, land development and building, and the expected long-term operations of the facility. The table depicts impacted wildlife species that may or may not be protected by state or federal guidelines, but have been deemed important by researchers as notable components of the biodiversity on KSC (Breininger et. al. 1994). There would undoubtedly be effects from the construction phase of the projects. These are expected to be temporary except for those caused by habitat removal and alteration.

Construction
Construction noise and activities would potentially have minimal impacts to raptor species such as owls and hawks which nest, roost and forage in the hammock areas of this

Table 4-2
Potential Wildlife Impacts

Common Name	Impacts							
	Proposed Action		Roads for Proposed Action		Alt. 1 (Contractor's Rd)		Alt. 2 (Headquarters)	
	Cons	Ops	Cons	Ops	Cons	Ops	Cons	Ops
BIRDS								
Barn Owl	L		L		L			
Barred Owl	M		M	L	L			
Common Ground Dove	L							
Cooper's Hawk	M		M		M			
Eastern American Kestrel	L			L	L			
Florida Scrub Jay	L			L	L			
Glossy Ibis			L	L				
Great Egret			L	L				
Great Horned Owl	M		M	L	M			
Little Blue Heron			L	L				
Loggerhead Shrike	L			L				
Pileated Woodpecker	M		M		M			
Red-shouldered Hawk	M		M		M			
Red-tailed Hawk	M		M	L	M			
Snowy Egret			L	L				
Tri-colored Heron			L	L				
White Ibis			L	L				
Wood Stork			L	L				
MAMMALS								
Bobcat	M		M	M	L			
Florida Long-tailed Weasle	L		L	L				
Florida Mouse	L			L				
River Otter	L		M	M				
Round-tailed Muskrat	L		M	M				
AMPHIBIANS								
Florida Gopher Frog	L							
REPTILES								
Eastern Coachwhip	L		L	L	L			
Eastern Diamondback Rattlesnake	L		L	L	L			
Eastern Indigo Snake	M		M	M	M			
Eastern Kingsnake	L		L	L	L			
Florida Pine Snake	L			L	L			
Gopher tortoise	M			M	L			
Mole Kingsnake	L		L	L	L			
KEY								
Impacts:								
L = Low, some impacts from noise or human activity, or some alteration in habitat but not significant to the success of the species								
M = Moderate, noise or other human activity that can impact important behavior or important habitat but will not cause significant changes in the population								
H = High, long term impacts from noise or human activity that causes a removal of species or that has a significant impact on the population								

site. Other wide-ranging species such as the bobcat and indigo snake may be impacted by habitat removal and construction activities. Many species are typically sensitive to human activity and will move away from disturbance, thus causing at least a temporary shift in the population structure.

Construction noise and activities of the proposed roads servicing this SERPL action would have minimal impacts to raptors, large mammals, and large snakes. Construction activity would remove habitat for these species, as well as increase disturbance around the area. The impacted species are typically sensitive to human activity and will move away from disturbance, thus causing at least a temporary shift in the population structure. Removal and alterations in the existing ditches may impact wading birds; however, this impact is expected to be minimal.

Operation

No impacts from the operation of the SERPL are expected for this Proposed Action.

The long-term operation of these roads would have the greatest impact on wildlife species. Roads fragment populations, increase mortality and provide avenues for opportunistic species that can out compete more habitat-specific species. Roads have a long-term effect on local population success for both large and small species by changing behavioral routes (dispersal, finding mates, foraging, etc.) that are necessary for survival. The inevitable changes in habitat structure along the road edges would likely alter habitat enough to change the species composition in some areas.

Biodiversity

Construction

Impacts to local biodiversity from land clearing and construction of the SERPL facility and associated road improvements are expected to be low to moderate (Table 4-3). Suitable habitat for at least 30 locally important species would be removed or altered during the construction phase. The construction impacts are not expected to cause major changes in the overall population size or structure of any of these species on the Space Center.

Operation

The operation of the facility itself is not expected to have any impacts on the biodiversity of the area. Operation of

TABLE 4-3
POTENTIAL WILDLIFE IMPACTS WITHIN SUITABLE HABITATS

SCIENTIFIC NAME	*COMMON NAME*	*LEVEL OF PROTECTION*	Citrus Groves	Electrical Power Transmission Lines	Hardwood - Conifer Mixed	Other Open Land	Palmetto Prairies	Pine Flatwoods	Stream and Lake Swamps (Bottomland)	Streams and Waterways	Xeric Oak	Cabbage Palm Savannah	Mowed Grass	Fire Break (Open Sand)
Amphibians and Reptiles														
Rana capito	Gopher frog	state	P	P		P	P	P, 1			P, 1			1
Alligator mississippiensis	American alligator	federal							P	P				
Caretta caretta	Atlantic loggerhead turtle	federal												
Chelonia mydas	Atlantic green turtle	federal												
Dermochelys coriacea	Leatherback turtle	federal												
Gopherus polyphemus	Gopher tortoise	state	P	P		P	P	P, 1			P, 1			1
Drymarchon corais couperi	Eastern indigo snake	federal	P	P	P	P	P	P, 1	P	P	P,1			1
Nerodia fasciata taeniata	Atlantic salt marsh snake	federal												
Pituophis melanoleucus mugitus	Florida pine snake	state	P	P	P	P		P,1			P			
Birds														
Pelecanus occidentalis	Brown pelican	state												
Egretta thula	Snowy egret	state								P				
Egretta caerulea	Little blue heron	state								P				
Egretta tricolor	Tricolored heron	state								P				
Egretta rufescens	Reddish egret	state												
Eudocimus albus	White ibis	state								P			3	
Ajaia ajaja	Roseate spoonbill	state												
Mycteria americana	Wood stork	federal								P				
Haliaeetus leucocephalus	Bald eagle	federal												
Falco peregrinus tundrius	Arctic peregrine falcon	state												
Falco sparverius paulus	Southeastern American kestrel	state		P										
Charadrius melodus	Piping plover	federal												
Sterna antillarum	Least tern	state												
Rynchops niger	Black skimmer	state												
Aphelocoma coerulescens coerulescens	Florida scrub-jay	federal		P				P, 1			P, 1			1
Mammals														
Peromyscus polionotus niveiventris	Southeastern beach mouse	federal												
Podomys floridanus	Florida mouse	state	P	P		P	P	P, 1			P, 1			1
Trichechus manatus	West Indian manatee	federal												
Key:														
P = Propsed action location														
1 = Alternative 1 location														
2 = Alternative 2 location														

the new road could have major impacts on the overall biodiversity of the area. At least 26 locally important species could be affected by the road operation, 11 of those species can expect moderate to high impacts that could result in major changes in population structure or behavior. The gravity of the impacts to biodiversity is in the duration of the road's effects. Impacts that would normally be minor are increased substantially due to the nature of roadway operations and their effect on the surrounding environment. Roads fragment populations, increase mortality and provide avenues for opportunistic species that can out compete more habitat-specific species. Roads have a long-term effect on local population success for both large and small species by changing behavioral routes (dispersal, finding mates, foraging, etc.) that are necessary for survival. The inevitable changes in habitat structure along the road edges would likely alter habitat enough to change the species composition in some areas.

4.2.4 Threatened and Endangered Species

Table 4-4 gives a summary of the level of impacts to protected species that can be expected from each alternative.

Construction

Minimal impacts can be expected on protected species during the construction phase of this project. Scrub-jays were documented in the area during the biological survey; however, habitat is not extensive [1.4 ha (3.4ac)]. Other species expected to experience minimal impacts are the Florida mouse and Florida gopher frog. These species, while typically found in conjunction with tortoise burrows, are not widely distributed throughout KSC and the likehood of their presence on site is low. The indigo snake, pine snake and gopher tortoise are all more susceptible to construction disturbances in and around this area and this activity would remove suitable habitat for these species.

Road construction would have a minimal impact on listed species. Some wading bird habitat would be removed, mostly in the form of ditches; however, that habitat would probably be replaced by new ditches. Road construction would also remove and cause a minimal disturbance in habitat suitable for the indigo snake and gopher tortoise which, in turn, may impact the Florida mouse and gopher frog.

Table 4-4
Potential Impacts to Threatened and Endangered Species

Common Name	Level of Protection	Impacts							
		Proposed Action		Roads for Proposed Action		Alternative 1 (Contractor's Rd)		Alternative 2 (Headquarters)	
		Constr	Ops	Constr	Ops	Constr	Ops	Constr	Ops
BIRDS									
Florida Scrub Jay	Federal	L				L			
Little Blue Heron	State			L	L				
Snowy Egret	State			L	L				
Tri-colored Heron	State			L	L				
White Ibis	State			L	L				
Wood Stork	Federal			L	L				
MAMMALS									
Florida Mouse	State	L		L	L	L			
AMPHIBIANS									
Florida Gopher Frog	State	L		L	L	L			
REPTILES									
Eastern Indigo Snake	Federal	M		L	M	L			
Florida Pine Snake	State	M		L	M	L			
Gopher Tortoise	State	M		L	M	L			
KEY									
Impacts:									
L = Low, some impacts from noise or human activity, or some alteration in habitat but not significant to the success of the species									
M = Moderate, noise or other human activity that can impact important behavior or important habitat but will not cause significant changes in the population									
H = High, long term impacts from noise or human activity that causes a removal of species or that has a significant impact on the population									

Operation
There are no expected impacts to threatened or endangered species due to the operation of the SERPL at the Proposed Action location.

The long-term operation of the proposed roads would have the greatest impact on protected species. Roads have a major, long-term impact on local populations of listed species, particularly the indigo snake, and to a lesser extent, the gopher tortoise. Increases in road mortality can be expected; however, this would not be the most severe impact to indigo snake populations in the area; rather habitat fragmentation would produce the greatest impact. Research by Barkaszi & Smith and Smith & Legare have found distinct avoidance patterns by indigo snakes when major roadways, such as the one proposed, intersects a home range. The proposed road would effectively change behavioral routes (dispersal, finding mates, foraging etc.) that are necessary for survival. The impact assessment matrix has been reduced from a major impact to a minor impact due to the mitigative measures, which will be addressed in the design phase of the road construction. The inevitable changes in habitat structure along the road edges would likely cause consequential changes in the species composition in some areas and would reduce the effectiveness of fire management in adjacent habitats.

4.2.5 Cultural Resources

Construction
The area proposed for this alternative site has been previously mapped by NASA to indicate its potential for containing historical artifacts. As a result of this study, the Proposed Action has been identified as having a low potential for impacts to cultural resources. In addition, there are no known historic or archaeological properties within the site. Therefore, no impacts to historic or archeological properties are expected.

Operation
The operation of the SERPL at the Proposed Action site is not expected to produce any impacts to cultural resources.

4.2.6 Geology and Soils

Construction
The only potential impact to the geology and soils of this site would be due to site preparation activities. Land clearing and excavation for facility foundations and stormwater systems would require that the upper layers of

the soil strata be removed. This alteration of the site may affect the flow patterns of surface runoff from rainfall events, but would be compensated for with the site grading and construction of a suitable stormwater system.

Operation
The operation of the SERPL at the Proposed Action site would not be expected to produce any impacts to the geologic strata or soils of the local area or region.

4.2.7 Noise

Construction
Ambient noise levels are expected to increase during construction activities and daily operations as a result of the SERPL being constructed. The noise generated by construction vehicles is expected to be below all noise thresholds and would occur for a brief period. EPA's recommended upper level noise threshold is 70 dBA, for a 24-hour timeframe (KSC 1997-A 1997). In addition, there are no known noise receptors (e.g., wildlife) in or around the site, which are especially sensitive to the expected noise levels. The potential impacts from the construction of the SERPL are therefore considered minor.

Operation
Noise levels for operations are expected to result from increased vehicle traffic and facility equipment (air conditioners, etc.). These two sources are expected to be similar to existing noise sources and therefore would have no impact to noise receptors.

4.2.8 Surface Water Quality

Construction
The construction of the SERPL facility would have minimal effects to the surface water quality at the Proposed Action site. These effects would be compensated for with the construction of a surface water management system, which would treat runoff due to the new impervious area of the facility. During actual construction activities, impacts to surface waters in the area would be minimized, by ensuring Best Management Practices (BMPs) are initiated and maintained, in order to control erosion and sedimentation.

Operation
The operation of the SERPL at the Proposed Action site would have no impacts to the surface water quality. The stormwater management system would be capable of treating all stormwater runoff.

4.2.9 Groundwater Quality

Construction
The groundwater quality at the Proposed Action site is affected by runoff from roadways and nearby existing facilities that percolates into the surficial aquifer. The construction of the SERPL would temporarily increase the amounts of sedimentation and pollutants that could migrate into the groundwater system. However, maintaining BMPs and the construction of the stormwater management system would inhibit this from occurring. Therefore, the construction of the SERPL at the Proposed Action site would have no impacts to groundwater quality.

Operation
Operations at the SERPL would generate pollutants typically created by vehicle traffic. The poor recharge ability in the area inhibits the migration of contaminants downward into the surficial aquifer and promotes their transport into the surface water management system that would be constructed along with the SERPL. There are no effects to groundwater quality expected for the operation of this facility.

4.2.10 Socioeconomics

Construction
The 100 to 150 construction workers expected during the construction of the SERPL would be drawn from the local workforce with an expected positive impact to the local economy. This is expected to have a minimal impact to socioeconomics and the workforce at KSC.

Operation
The programs to be located at the SERPL already exist at KSC and only involve centralizing personnel in one location. The additional personnel to support the Space Station Program will increase the amount of personnel by 30, and represents a 30 percent increase which is considered to be a minimal increase. Therefore, the increased number of people on KSC resulting from this action is expected to have minimal impacts to the KSC workforce.

4.2.11 Land Use

Construction
Only a relatively small portion of the total acreage of KSC has been developed or designated for NASA operational and industrial use. Of the 56,600 ha (140,000 ac) of total KSC area, less than 5 percent is designated for KSC operational

area and only 62 percent of this area has been developed. The approximately 16.18 ha (40 ac) site for the SERPL would increase this area from approximately 62 percent to 62.6 percent. The construction of the SERPL at the Proposed Action site would require removing the 16.18 ha (40 ac) site from the MINWR. This would consist of removing the area from under the management of the MINWR and would end all land management actions completed by the Fish and Wildlife Service (FWS). The impacts to land use at KSC as a result of the construction of this facility are expected to be minor.

KSC is within the Coastal Zone as defined by Florida Statutes (15 CFR 930.30-44). As such, a Coastal Zone Consistency Determination is required (FDER 1984). The results indicate that the proposed action can be implemented within existing environmental regulations and has been determined to be consistent with the Florida Coastal Zone Management Plan.

Operation
The operation of the SERPL at the Proposed Action site would have no impacts to the land use.

4.3 Alternative 1

4.3.1 Facilities and Infrastructure

Transportation

Construction
The construction of the SERPL at the Alternative 1 location would have no expected impacts to transportation at and around the facility. Increased construction traffic would occur during normal working hours and may cause some traffic delays. However, the capacity of all affected roads is not expected to be exceeded by this increase in vehicles.

Operation
The operation of the SERPL at the Alternative 1 location is expected to produce only minimal impacts to roads on KSC as the number of vehicles entering the Center is not expected to increase. There would be a shift of traffic currently associated with Hangar L on CCAFS and the O&C Building in the KSC Industrial Area. However, as this is all internal to the Cape Canaveral Spaceport, this is not expected to cause any traffic delays.

Utilities

Construction
The construction of the SERPL at the Alternative 1 location would require connections to wastewater, electrical, communication, and potable water utilities. There are power and communication lines located on the east side of Contractors Road, adjacent to the Alternative 1 location. There is an existing wastewater line on the west side of Contractors Road. There is a potable water main on the east side of SR 3. The construction at this site is expected to present minimal impacts to these utilities.

Operation
The operation of the SERPL at the Alternative 1 location is expected to have no impacts to the utilities.

4.3.2 Air Quality

Construction
The site preparation and construction of the SERPL facility at the Alternative 1 location would produce minimal impacts to the surrounding air quality. The clearing of land and other construction activities would generate airborne particulates from earth moving as well as hydrocarbon exhaust from heavy equipment. Such activities are expected to be minimal in scope and of short duration. BMP's would also be employed to mitigate for emissions due to earth movement. These BMP's include water spraying, placement of hay bales, and other forms of dust control.

Operation
The operation of the SERPL at the Alternative 1 location is not expected to have any impacts to the surrounding air quality.

4.3.3 Biological Resources

Vegetation

Construction
Construction activities at the 25- acre site would result in the removal of some area of several biological community types available on the Space Center as follows:

Community Type	Hectares	Acres
Pine flatwoods	8.8	21.7
Cabbage palm savanna	0.2	0.6
Developed governmental land	0.7	1.9
Xeric oak scrub	0.3	0.7
Existing roadway	0.3	0.9

Impacts to the area would be minimized by selective clearing for a facility design that maintains as much existing, native vegetation as possible. These construction activities are expected to produce minor impacts to vegetation at the Alternative 1 location.

Operation

No impacts to vegetation are expected from the operation of the SERPL. Removal of this site from the refuge management program may influence the effectiveness of fire in managing adjacent habitats due to an increase in edge effects. However, as this area is already outside the Refuge as defined by the Cooperative Agreement, it is not managed by the Refuge. Operations occurring in the SERPL could limit the ability to use prescribed burning in adjacent habitats, such as particulate concerns in clean rooms or other similar facilities within the SERPL. Facility design would incorporate technology to allow prescribed burning in the nearby landscape to minimize these impacts to Refuge operations.

Wetlands and Floodplains

Construction

No wetland or floodplain impacts are expected from construction at the Alternative 1 location.

Operation

No wetland or floodplain impacts are expected from the operation of the SERPL facility at the Alternative 1 location.

Wildlife

Construction

Construction noise and activities would potentially have minor impacts on raptor species such as owls and hawks and woodpecker species which nest, roost and forage in the pine flatwoods areas of this site. Construction activity would remove habitat for these species as well as increase disturbance around the area. The impacted species are typically sensitive to human activity and would be expected

to move away from such disturbance, thus causing at least a temporary shift in population structure.

Operation
No wildlife impacts are expected due to the operation of the SERPL facility at the Alternative 1 location.

Biodiversity
Construction
Impacts to local biodiversity from land clearing at the Alternative 1 site are expected to be low to moderate (Table 4-2). Suitable habitat for at least 17 locally important species would be removed or altered during the construction phase. The construction impacts are not expected to cause consequential changes in the overall population size or structure of any of these species on the Space Center.

Operation
No long term impacts to local biodiversity are expected to occur from the operation of the SERPL facility at the Alternative 1 site location.

4.3.4 Threatened and Endangered Species

Construction
Minor impacts can be expected for the Florida Scrub-jay due to construction at the Alternative 1 location. Only two individuals were seen on site during the biological survey and the amount of habitat is likely to constitute only a small portion of one family's territory. Minor impacts can also be expected for the gopher tortoise and associated fauna, including the indigo snake, Florida mouse and gopher frog. Due to the maturity of pines and habitat structure, pine snakes may also incur minor impacts during construction.

Operation
No threatened or endangered species impacts are expected due to the operation of the SERPL facility at the Alternative 1 location.

4.3.5 Cultural Resources

Construction
This area has been previously mapped by NASA to indicate its potential for containing historical artifacts. As a result of this study, the Alternative 1 location has been identified as having a low potential for impacts to cultural resources. In addition, there are no known historic or

archaeological properties within the site. Therefore, no impacts to historic or archeological properties are expected.

Operation
The operation of the SERPL at the Alternative 1 location would have no impacts to cultural resources.

4.3.6 Geology and Soils

Construction
The only potential impact to the geology and soils of this site would be due to site preparation activities. Land clearing and excavation for facility foundations and stormwater systems would require that the upper layers of the soil strata be removed. This alteration of the site may effect the flow patterns of surface runoff from rainfall events, but would be compensated for with the site grading and construction of a suitable stormwater system.

Operation
The operation of the SERPL at the Alternative 1 location would have no impacts to the geologic strata or soils.

4.3.7 Noise

Construction
Ambient noise levels are expected to increase during construction activities and daily operations as a result of the SERPL being constructed. The noise generated by construction vehicles is expected to be below all noise thresholds and would occur for a brief period. EPA's recommended upper level noise threshold is 70 dBA, for a 24-hour timeframe (KSC 1997-A 1997). In addition, the existing wildlife known to occupy the site are not especially sensitive to the expected noise levels. The potential impacts from the construction of the SERPL at the Alternative 1 location are therefore considered minor.

Operation
Noise levels for operations are expected to result from increased vehicle traffic and facility equipment (air conditioners, etc.). These two sources are expected to be similar to existing noise sources and therefore would have no impact to noise receptors.

4.3.8 Surface Water Quality

Construction
The construction of the SERPL facility would have minimal effects to the surface water quality at the Alternative 1 location. These effects would be compensated for with the construction of a surface water management system, which would treat runoff due to the new impervious area of the facility. During actual construction activities, impacts to surface waters in the area would be minimized, by ensuring BMPs are initiated and maintained, in order to control erosion and sedimentation.

Operation
The operation of the SERPL at the Alternative 1 location would have no impacts to the surface water quality. The stormwater management system would be capable of treating all stormwater runoff.

4.3.9 Groundwater Quality

Construction
The groundwater quality at the Alternative 1 location is affected by runoff from roadways and nearby existing facilities that percolates into the surficial aquifer. The construction of the SERPL would temporarily increase the amounts of sedimentation and pollutants that could migrate into the groundwater system. However, maintaining BMPs and the construction of the stormwater management system would inhibit this from occurring. Therefore, the construction of the SERPL at the Alternative 1 location would have no impacts to groundwater quality.

Operation
Operations at the SERPL would generate pollutants typically created by vehicle traffic. The poor recharge ability in the area inhibits the migration of contaminants downward into the surficial aquifer and promotes their transport into the surface water management system that would be constructed along with the SERPL. There are no effects to groundwater quality expected for the operation of this facility at the Alternative 1 location.

4.3.10 Socioeconomics

Construction
The 100 to 150 construction workers expected during the construction of the SERPL would be drawn from the local workforce with an expected positive impact to the local

economy. This is expected to have a minimal impact to socioeconomics and the workforce at KSC.

Operation
The programs to be located at the SERPL already exist at KSC and only involve centralizing personnel in one location. The additional personnel to support the Space Station Program will increase the amount of personnel by 30, and represents a 30 percent increase which is considered to be a minimal increase. Therefore, the increased number of people on KSC resulting from this action is expected to have minimal impacts to the KSC workforce.

4.3.11 Land Use

Construction
The Alternative 1 location is already designated for NASA operational and industrial use. Therefore, the construction of the SERPL at this location would have no expected impacts to the land use.

KSC is within the Coastal Zone as defined by Florida Statutes (15 CFR 930.30-44). As such, a Coastal Zone Consistency Determination is required (FDER 1984). The results indicate that the proposed action can be implemented within existing environmental regulations and has been determined to be consistent with the Florida Coastal Zone Management Plan.

Operation
The operation of the SERPL at the Alternative 1 location would have no impacts to the land use.

4.4 Alternative 2

4.4.1 Facilities and Infrastructure

Transportation

Construction
The construction of the SERPL at the Alternative 2 location would have no expected impacts to transportation at and around the facility. Increased construction traffic would occur during normal working hours and may cause some traffic delays. However, the capacity of all affected roads is not expected to be exceeded by this increase in vehicles.

Operation
The operation of the SERPL at the Alternative 2 location would have no expected impacts to transportation. There would be a shift of traffic currently associated with Hangar L on CCAFS and the O&C Building in the KSC Industrial Area. However, as this is all internal to the Cape Canaveral Spaceport, this is not expected to cause any traffic delays.

Utilities

Construction
The construction of the SERPL at the Alternative 2 location would require connections to wastewater, electrical, communication, and potable water utilities. There are power, communication, wastewater, and potable water lines located on the 2nd Street, adjacent to the Alternative 2 location. The construction at this site is expected to present minimal impacts to these utilities.

Operation
The operation of the SERPL at the Alternative 2 location is expected to have no impacts to the utilities.

4.4.2 Air Quality

Construction
The construction of the SERPL at the Alternative 2 location is not expected to have any impacts to the surrounding air quality. Minimal site preparation would be required. The clearing of land and other construction activities would generate airborne particulates from earth moving as well as hydrocarbon exhaust from heavy equipment. Such activities are expected to be minimal in scope and of short duration. BMP's would also be employed to mitigate for emissions due to earth movement. These BMP's include water spraying, placement of hay bales, and other forms of dust control.

Operation
The operation of the SERPL at the Alternative 2 location is not expected to have any impacts to the surrounding air quality.

4.4.3 Biological Resources

Vegetation

Construction
There would be no impacts to vegetation due to the construction of the SERPL facility at the Alternative 2

location. Only ruderal habitat (mowed grass) would be impacted by construction activities.

Operation
There would be no impacts to vegetation from the operation of the SERPL facility at the Alternative 2 location.

Wetlands and Floodplains

Construction
No wetland or floodplain impacts are expected from construction activities at the Alternative 2 location.

Operation
No wetland or floodplain impacts are expected due to the operation of the SERPL facility at the Alternative 2 location.

Wildlife

Construction
No impacts to wildlife are expected due to construction activities at the Alternative 2 location.

Operation
No impacts to wildlife are expected due to the operation of the SERPL at the Alternative 2 location.

Biodiversity

Construction
No impacts to local biodiversity are expected to occur from the land clearing and construction of the SERPL facility at the Alternative 2 site location (Table 4-2).

Operation
No long term impacts to local biodiversity are expected to occur from the operation of the SERPL facility at the Alternative 2 site location.

4.4.4 Threatened and Endangered Species

Construction
No impacts to protected species are expected due to construction activities at the Alternative 2 location.

Operation
No impacts to protected species are expected due to the operation of the SERPL at the Alternative 2 location.

4.4.5 Cultural Resources

Construction
This area has been previously mapped by NASA to indicate its potential for containing historical artifacts. As a result of this study, the Alternative 2 location has been identified as having a low potential for impacts to cultural resources. In addition, there are no known historic or archaeological properties within the site. Therefore, no impacts to historic properties are expected.

Operation
The operation of the SERPL at the Alternative 2 location would have no impacts to cultural resources.

4.4.6 Geology and Soils

Construction
The only potential impact to the geology and soils of this site would be due to site preparation activities. Excavation for facility foundations would require that the upper layers of the soil strata be removed.

Operation
The operation of the SERPL at the Alternative 2 location would have no impacts to the geologic strata or soils.

4.4.7 Noise

Construction
Ambient noise levels are expected to increase during construction activities and daily operations as a result of the SERPL being constructed. The noise generated by construction vehicles is expected to be below all noise thresholds and would occur for a brief period. EPA's recommended upper level noise threshold is 70 dBA, for a 24-hour timeframe (KSC 1997-A 1997). There are no expected impacts to noise receptors due to the construction of the SERPL at the Alternative 2 location.

Operation
Noise levels for operations are expected to result from increased vehicle traffic and facility equipment (air conditioners, etc.). These two sources are expected to be similar to existing noise sources and therefore would have no impact to noise receptors.

4.4.8 Surface Water Quality

Construction
The construction of the SERPL facility would have no effects to the surface water quality at the Alternative 2 location. This alteration of the site may affect the flow patterns of surface runoff from rainfall events, but would be compensated for with the site grading and construction of a conveyance system to the Region 1 Stormwater System. During actual construction activities, impacts to surface waters in the area would be minimized, by ensuring BMPs are initiated and maintained, in order to control erosion and sedimentation.

Operation
The operation of the SERPL at the Alternative 2 location would have no impacts to the surface water quality.

4.4.9 Groundwater Quality

Construction
The groundwater quality at the Alternative 2 location is affected by runoff from roadways and nearby existing facilities that percolates into the surficial aquifer. The construction of the SERPL would temporarily increase the amounts of sedimentation and pollutants that could migrate into the groundwater system. However, maintaining BMPs and the construction of a conveyance to the Region 1 stormwater system would inhibit this from occurring. Therefore, the construction of the SERPL at the Alternative 2 location would have no impacts to groundwater quality.

Operation
Operations at the SERPL would generate pollutants typically created by vehicle traffic. The poor recharge ability in the area inhibits the migration of contaminants downward into the surficial aquifer and promotes their transport into the existing Region 1 stormwater system. There are no effects to groundwater quality expected for the operation of this facility.

4.4.10 Socioeconomics

Construction
The 100 to 150 construction workers expected during the construction of the SERPL would be drawn from the local workforce with an expected positive impact to the local economy. This is expected to have a minimal impact to socioeconomics and the workforce at KSC.

Operation
The programs to be located at the SERPL already exist at KSC and only involve centralizing personnel in one location. The additional personnel to support the Space Station Program will increase the amount of personnel by 30, and represents a 30 percent increase which is considered to be a minimal increase. Therefore, the increased number of people on KSC resulting from this action is expected to have minimal impacts to the KSC workforce.

4.4.11 Land Use

Construction
The Alternative 2 location is already designated for NASA operational and industrial use. Therefore, the construction of the SERPL at this location would have no expected impacts to the land use.

KSC is within the Coastal Zone as defined by Florida Statutes (15 CFR 930.30-44). As such, a Coastal Zone Consistency Determination is required (FDER 1984). The results indicate that the proposed action can be implemented within existing environmental regulations and has been determined to be consistent with the Florida Coastal Zone Management Plan.

Operation
The operation of the SERPL at the Alternative 2 location would have no impacts to the land use.

4.5 No Action

There will be a major impact to the Shuttle Program and the ISS Program if the No Action Alternative is the chosen alternative. The existing facilities are extremely inadequate for the processes, which are necessary to conduct payload experiments preparation and testing.

4.5.1 Facilities and Infrastructure

There would be no expected impacts to transportation or utilities for the No Action Alternative. No construction would occur and the facilities presently being used to support the STS and ISS life sciences research have all utility connections required.

4.5.2 Air Quality

There would be no expected impacts to air quality for the No Action Alternative. The additional vehicular traffic expected with the increase in personnel to support the ISS is not expected to measurably increase emissions.

4.5.3 Biological Resources

Vegetation

There would be no expected impacts to vegetation for the No Action Alternative.

Wetlands and Floodplains

There would be no expected impacts to wetlands or floodplains for the No Action Alternative.

Wildlife

There would be no expected impacts to wildlife for the No Action Alternative.

Biodiversity

There would be no expected impacts to Biodiverity for the No Action Alternative.

4.5.4 Threatened and Endangered Species

There would be no expected impacts to threatened or endangered for the No Action Alternative.

4.5.5 Cultural Resources

There would be no expected impacts to cultural resources for the No Action Alternative.

4.5.6 Geology and Soils

There would be no expected impacts to geology or soils for the No Action Alternative. There would be no construction associated with this Alternative.

4.5.7 Noise

There would be no expected impacts to noise for the No Action Alternative. There would be no construction associated with this Alternative and the operation of the

existing facilities are within industrial areas with no noise receptors.

4.5.8 Surface Water Quality

There would be no expected impacts to surface water quality for the No Action Alternative. There would be no construction associated with this Alternative. No additional stormwater would be generated and require treatment.

4.5.9 Groundwater Quality

There would be no expected impacts to groundwater quality for the No Action Alternative. There would be no construction and no chance of increased pollutant loadings getting into the groundwater, associated with this Alternative.

4.5.10 Socioeconomics

There would be no expected impacts to socioeconomics for the No Action Alternative.

4.5.11 Land Use

There would be no expected impacts to land use for the No Action Alternative. The existing facilities utilized to support STS life sciences would also house additional personnel to support ISS life sciences. No construction would occur for this alternative.

5.0 ENVIRONMENTAL JUSTICE

On February 11, 1994, the President of the United States signed EO 12898, entitled, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." The general purposes of the EO are to: 1) focus the attention of Federal Agencies on the human health and environmental conditions in minority communities and low-income communities with the goal of achieving environmental justice; 2) foster non-discrimination in Federal programs that substantially affect human health or the environment; and 3) give minority communities and low-income communities greater opportunities for public participation in and access to, public information on matters relating to human health and the environment.

The EO directs Federal Agencies, including NASA, to develop environmental justice strategies. Further, EO 12898 requires NASA, to the greatest extent practicable and permitted by law, to make the achievement of environmental justice part of NASA's mission by identifying and addressing, as appropriate, disproportionately high adverse human health or environmental effects on minority or low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.

In accordance with EO 12898, NASA established an agency-wide strategy, which, in addition to the requirements set forth in the EO, seeks to: 1) minimize administrative burdens; 2) focus on public outreach and involvement; 3) encourage implementation plans tailored to the specific situation at each center; 4) make each center responsible for developing its own Environmental Justice Plan; and, 5) consider both normal operations and accidents.

In turn, KSC has developed a plan to comply with the EO and NASA's agency-wide strategy. As part of that plan, the impacts to low-income and minority populations in the KSC area were addressed as part of this EA. This project, for all alternatives addressed, would be implemented within the boundaries of KSC. The closest residential areas are 13 km (9.5 mi) to the south on Merritt Island and 12 km (7.6 mi) to the west in Titusville. No groups of either low-income or minority populations have been identified in either location. In addition, the distances of these areas from the Proposed Action preclude any direct impacts from construction or operations. Economic impacts are not expected to adversely affect any particular group.

Construction personnel would be drawn from the local workforce and provide a short-term economic benefit to the local area. Operational personnel would be increased only for the ISS life sciences activities planned to be housed in the SERPL.

6.0 PREPARERS, CONTRIBUTORS, AND CONTACTs

The individuals from KSC who provided detailed data or analyses and who prepared this document are listed in Table 6-1. The table provides information concerning which section(s) each person was involved in writing or assembling.

TABLE 6-1
List of Preparers

Preparers	Affiliation	Professional Title	Contribution
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Schroeder, Wally	Jones Edmund and Associates	Engineer	Document, Facility Engineering
Shaffer, John	SGS Environmental Services	Environmental Engineer	Field Assessment
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APPENDIX A
TYPICAL WILDLIFE SPECIES

Common Name	Federal Listing Status	State Listing Status	Impacts				
			Proposed Action	Roads for Proposed Action	Alt. 1 (Contractor's Rd)	Alt. 2 (Headquarters)	No Action
BIRDS							
American Avocet							
American Oyster Catcher		SSC					
Artic Peregrine Falcon	T	E					
Barn Owl			L	L	L		
Barred Owl			L	M	L		
Black Rail							
Black Skimmer		SSC					
Black-bellied Plover							
Black-crowned Night Heron							
Black-necked Stilt							
Black-whiskered Vireo							
Caspian Tern							
Common Ground Dove			L				
Common Loon							
Cooper's Hawk			L	M	M		
Eastern American Kestrel			L		L		
Eastern Brown Pelican		SSC					
Florida Prairie Warbler							
Florida Scrub Jay	T	T	L		L		
Glossy Ibis				L			
Great Egret				L			
Great Horned Owl			L	M	M		
Gull-billed Tern							
King Rail							
Least Bittern							
Least Tern		T					
Little Blue Heron		SSC		L			
Loggerhead Shrike			L				
Marbled Godwit							
Merlin							
Northern Harrier							
Osprey							
Pileated Woodpecker			M	M	M		
Piping Plover	T	T					
Red Knot							
Reddish Egret		SSC		L			
Red-shouldered Hawk			M	M	M		
Red-tailed Hawk			M	M	M		
Roseate Spoonbill		SSC					
Royal Tern							
Sanderling							
Sandwich Tern							
Short-billed Dowitcher							
Snowy Egret		SSC		L			
Southern Bald Eagle	T	T					

Impacts (Continued)							
Common Name	**Federal Listing Status**	**State Listing Status**	**Proposed Action**	**Roads for Proposed Action**	**Alt. 1 (Contractor's Rd)**	**Alt. 2 (Headquarters)**	**No Action**
Tri-colored Heron		SSC		L			
Western Sandpiper							
Whimbrel							
White Ibis		SSC		L			
Wilson's Plover							
Wood Stork	E	E		L			
MAMMALS							
Bobcat			M	M	L		
Florida Long-tailed Weasle			L	L			
Florida Mouse		SSC	L				
River Otter			L	M			
Round-tailed Muskrat			L	M			
Southeastern Beachmouse	T	T					
West Indian Manatee	E	E					
AMPHIBIANS							
Florida Gopher Frog		SSC	L				
REPTILES							
American Alligator	T (s/a)	SSC					
Atlantic Green Turtle	E	E					
Atlantic Loggerhead Turtle	T	T					
Atlantic Salt Marsh Snake	T	T					
Dusky Pygmy Rattlesnake							
Eastern Coachwhip			L	L	L		
Eastern Diamondback Rattlesnake			L	L	L		
Eastern Indigo Snake	T	T	M	M	M		
Eastern Kingsnake			L	L	L		
Florida East Coast Terrapin							
Florida Pine Snake		SSC	L		L		
Gopher tortoise		T	M		L		
Mole Kingsnake			L	L	L		
KEY							
Listing Status:							
E = Endangered							
T = Threatened							
SSC = Species of Special Concern							
Impacts:							
L = Low, some habitat loss but not significant to species continued existence							
M = Moderate, habitat loss that may include foraging, nesting or other important habitat but will not cause significant changes in the population							
H = High, critical habitat loss or direct removal of species that has a significant impact on the population							